Comparison of Medicare Spending and Outcomes for Beneficiaries with Lower Extremity Joint Replacements

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RAND HEALTH

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I. Executive Summary

Last year, the Centers for Medicare and Medicaid Services (CMS) released a regulation revising the definition of an inpatient rehabilitation facility (IRF) for payment purposes under the Medicare program. Specifically, the revised regulation (known as the "75 percent rule") replaced *polyarthritis*, one of the 10 conditions that had to constitute 75 percent of a facility's patients, with four arthritis-related conditions. The change was highly controversial. IRF industry leaders charged that the regulation would lead to reduced access to IRF care for lower extremity joint replacement (LEJR) patients. They claimed that LEJR had been implicitly included under the polyarthritis definition since arthritic joints are replaced. Under the revised definition, however, only LEJR patients with certain risk factors will be counted towards the threshold, which could lead to a reduction in access to IRF care for LEJR patients. CMS has pointed out that all types of LEJR patients can continue to receive rehabilitative care in skilled nursing facilities — a setting some have suggested might be a more appropriate site of care for uncomplicated joint replacements.

The primary objective of this study is to conduct a set of analyses comparing costs and outcomes of lower extremity joint replacement patients discharged to three different post-acute settings: inpatient rehabilitation facilities, skilled nursing facilities, and patient homes. We employ multivariate techniques in order to adjust these analyses for observable differences in severity of illness across sites of care. In doing so, we use multinomial models that predict which type of institutional post-acute care a beneficiary accesses, and we describe these predictors. In addition, we use instrumental variables (IV) techniques that allow us to account for unobserved patient selection into IRFs and SNFs in order to learn how patient costs and outcomes are affected by the availability of IRF and SNF care.

We analyzed data on elderly Medicare joint replacement patients discharged from hospitals between January 2002 and June 2003. Approximately 30 percent of the sample used SNF care, 35 percent used IRF care, and the remainder returned home (either with home health care or without any Medicare-paid post-acute care). We assembled, and included as independent variables in our models, a wide array of indicators of clinical, individual, discharging hospital, and PAC supply factors that might affect PAC choices. We created indicators for the outcomes death and institutionalization within 60 and 120 days of acute discharge. We then combined these two variables (institutionalization and mortality) into a composite measure since just examining the institutionalization variable for the population of survivors would result in a biased subsample. Using the home health, skilled nursing, and inpatient rehabilitation standard analytic files and hospital claims, we built length of stay and payment variables for each site of care for each beneficiary with an acute admission for lower-extremity joint replacement in 2002 or 2003. To account for selection on the basis of unobservable patient characteristics, we develop an IV model that uses the variation in proximity to IRFs and SNFs as a natural experiment. The resulting model examines whether patients who go IRFs and SNFs because of their proximity to these facilities have different outcomes and costs than patients who go home.

Our results indicate that there are differences in costs and possibly in outcomes across PAC sites for LEJR patients. The unadjusted data show that patients whose first site of care is an IRF or SNF have higher rates of mortality or care in an institutional setting 120 days after discharge from acute care compared to patients who receive care at home. However, our analysis suggests that these results are primarily driven by observed and unobserved differences in severity of illness and patient health at admission across sites of care. The apparently deleterious effects of IRFs and SNFs diminish significantly in our IV models that attempt to control for patient selection on both observable and unobservable characteristics. In particular, we find that after controlling for patient selection there no statistically significant differences in mortality rates across patients in different sites of post-acute care. However, the results from the IV models suggest that patients in IRFs and SNFs are more likely to be institutionalized. In particular the results indicate that compared to patients at home, patients in IRFs and SNFs are more likely to be to be dead or institutionalized at post-discharge day 120 by 0.18 percentage points and 0.46 percentage points respectively.

The results from the models of Medicare payments show that episodes of post-acute care in an IRF or SNF are much more expensive than episodes of care for patients who receive care at home or in a non-institutional setting. The results from the IV model that accounts for selection both on observable and unobservable patient characteristics show that total Medicare post-acute care payments (for 120 day episodes of care following acute discharge) for IRF and SNF patients were $8,023 and $3,578 respectively higher than Medicare payments for patients in the reference group who were discharged home. The results are similar when one compares total Medicare payments for the acute stay plus post-acute care. Finally, these results also highlight the importance of controlling for patient selection, although controlling for selection had a smaller effect in the payment models compared to the outcome models.

It is important in evaluating these findings to understand a key limitation of studies of health outcomes based on observational data: controlling fully for selection is extremely difficult. Our best estimates of the causal effect of PAC on outcomes are the IV models, but we cannot rule out the possibility that some selection remains in these estimates. Outcomes depend on many factors, including patients' physical and cognitive abilities, underlying medical diseases, sensory and emotional factors, willingness to participate in care, and supportive environments. No risk adjustment approach can control for every factor affecting outcomes of care. While our choice of instrumental variables was carefully considered to address this problem, our estimates could be biased if our instruments are invalid.

Another limitation of the study is that the outcomes we analyzed are not the ideal outcomes for LEJR patients. We would have preferred to examine functional status and changes therein, but we did not have the necessary data. Death and institutionalization at 120 days are imperfect proxies for functional decline and are likely to be less closely related than functional status to the surgical procedure and the rehabilitation process. In addition, our outcome measures do not capture other dimensions of quality of life. The evidence from our unadjusted functional measures suggests that patients going to IRFs and SNFs experience a short-term increase in functional status, with IRF patients beginning their stays with a lower level of functioning and achieving with a higher level of functioning than SNF patients over a similar period of time.

Finally, we underscore that our results do not apply to all patients who use IRFs or SNFs. Rather, our IV models show the effects of IRF and SNF use for *marginal* patients. In this context, marginal patients are those whose decision to use IRF or SNF is swayed by the proximity and availability of these PAC sites. Thus our results apply to patients for whom, in a sense, the clinical decision is gray. They do not apply to patients who are ideal candidates for IRF or who clearly require SNF care. Rather than being a limitation of our analysis, our focus on the marginal patient is an asset from a policy decision-making perspective since it is precisely these patients who will likely be affected by the reduced accessibility of IRF care as the 75 percent rule is enforced.

Our analyses of costs have limitations as well. We have not captured the costs of physician, outpatient and hospice care. If patients not using institutional PAC rely more heavily on those types of care, then our findings overstate the degree to which IRF and SNF episodes of care are more expensive. If patients in IRFs and SNFs are using these services after their stay, our findings could understate costs for these patients.   However, we do include costs of home health care, which is used at comparable rates by patients regardless of discharge destination. It seems reasonable to believe that use of outpatient and hospice care is likewise comparable across all categories of patients (i.e., those use institutional PAC and those who do not).

Ultimately, in order to fully assess the impact of the 75 percent rule, we would need three additional types of information. First, we would ideally measure real resource use across sites of care rather than measuring only Medicare payments. Second, we would need a method for evaluating the trade-off between better outcomes and higher costs. Finally, we would need better measures of outcomes, including a measure of functional status that was captured consistently across all discharge settings.

II. Introduction

Last year, the Centers for Medicare and Medicaid Services (CMS) released a regulation revising the definition of an inpatient rehabilitation facility (IRF) for payment purposes under the Medicare program. Specifically, the revised regulation (known as the "75 percent rule") replaced *polyarthritis*, one of the 10 conditions that had to constitute 75 percent of a facility's patients, with four arthritis-related conditions. The change was highly controversial. IRF industry leaders charged that the regulation would lead to reduced access to IRF care for lower extremity joint replacement (LEJR) patients. They claimed that LEJR had been implicitly included under the polyarthritis definition since arthritic joints are replaced. Under the revised definition, however, only LEJR patients with certain risk factors will be counted towards the threshold, which could lead to a reduction in access to IRF care for LEJR patients. CMS has pointed out that all types of LEJR patients can continue to receive rehabilitative care in skilled nursing facilities — a setting some have suggested might be a more appropriate site of care for uncomplicated joint replacements.

The primary objective of this study is to compare costs and outcomes of lower extremity joint replacement (LEJR) patients treated in inpatient rehabilitation facilities (IRFs) and skilled nursing facilities (SNFs) with those returning to their homes after surgery. We employ multivariate techniques in order to adjust these analyses for observable differences in severity of illness across sites of care. In doing so, we use multinomial models that predict which type of institutional post-acute care a beneficiary accesses, and we describe these predictors. In addition, we use instrumental variables techniques that allow us to account for unobserved patient selection into IRFs and SNFs in order to learn how patient costs and outcomes are affected by the availability of IRF and SNF care in an area. From a policy perspective, these analyses answer questions similar to the ones raised by the 75 percent rule – i.e., what is the effect on costs and outcomes of making IRF care less "accessible" to LEJR patients.

III. Background

Below we provide additional detail about the origins and provisions of the 75 percent rule regulation and information about the limited amount of research conducted to date on the outcomes of post-acute care after lower extremity joint replacement – or the outcomes of post-acute care in general.

75 Percent Rule Legislation

The Social Security Act gives the Secretary of Health and Human Services the discretion to define a rehabilitation hospital and unit. Hospitals and units meeting those criteria are eligible to be paid on a prospective payment basis as an IRF under the IRF PPS. Specifically, Section §412.23(b)(2) of Medicare regulation specifies one of the criteria Medicare uses for classifying a hospital or unit of a hospital as an IRF, commonly known as the "75 percent rule." This 75% rule was put in place more than 20 years ago when Medicare's prospective payment system (PPS) for acute care hospitals was implemented. Its purpose was to help define those facilities that are excluded from the acute PPS as rehabilitation facilities. A facility may be classified as an IRF if it can show that, during its most recent 12-month cost reporting period, it served an inpatient population of whom at least 75 percent required intensive rehabilitation services for the treatment of one or more of the following ten conditions:

- Stroke
- Spinal cord injury
- Congenital deformity
- Amputation
- Major multiple trauma
- Fracture of femur (hip fracture)
- Brain injury
- Polyarthritis, including rheumatoid arthritis
- Neurological disorders, including multiple sclerosis, motor neuron diseases, polyneuropathy, muscular dystrophy, and Parkinson's disease
- Burns

The August 7, 2001 final rule that implemented the IRF PPS did not change the survey and certification procedures for classification as an IRF. However, its implementation did increase attention to IRF regulations and enforcement of the existing 75 percent rule. CMS found that the rule was being enforced unevenly, and the prospect of stringent and uniform enforcement quickly brought to the fore that very few IRFs would be in compliance with an interpretation of “polyarthritis” that did not include lower extremity joint replacement. Indeed, only 13 percent of IRFs would qualify under such a definition (CMS Final Rule, April 30, 2004). A series of discussions, administrative actions, and moratoria on enforcement ensued culminating in a final rule issued in April 2004.

The regulation issued in April 2004 removed "polyarthritis" and added four arthritis-related medical conditions, resulting in 13 "qualifying" medical conditions used to classify a facility as an IRF. For example, Medicare will now count a patient towards the compliance threshold if the patient has severe or advanced osteoarthritis involving two or more major joints (elbows, shoulders, hips, or knees, but not counting a joint that has been replaced), and have met other medical criteria outlined in the regulation. Hip replacement patients with a preceding hip fracture count towards the compliance threshold. The final rule also provides for a transition to targeting payments to facilities that treat a large share of patients with diagnoses likely to require intensive rehabilitation.[1]

The 2004 final rule counts toward the compliance threshold certain patients who undergo knee or hip joint replacement, or both, during an acute hospitalization immediately preceding the IRF stay, and if they meet one or more of three conditions. The set of categories defined by CMS excludes lower extremity joint replacement patients except in cases of bilateral knee or hip replacements, extremely obese patients, or those over age 85. Other joint replacement patients do not count towards the 75 percent

[1] In the first year, the final rule requires only a limited percentage of patients of an IRF's total patient population to have one of the qualifying medical conditions in order for a facility to be classified as an IRF. For cost reporting periods beginning on or after July 1, 2004, and before July 1, 2005, the compliance threshold is set at 50 percent of the IRF's total patient population. For cost reporting periods beginning on or after July 1, 2005, and before July 1, 2006, the compliance threshold is set at 60 percent of the IRF's total patient population. For cost reporting periods beginning on or after July 1, 2006, and before July 1, 2007, the compliance threshold is set at 65 percent of the IRF's total patient population (CMS Final Rule, April 30, 2004).

rule unless they have other qualifying conditions (these other conditions include hip fracture as the event precipitating a hip replacement). As we discuss below, relatively few joint replacements are bilateral procedures and over one hundred thousand patients with single replacements use IRF care each year. In fact, LEJRs are now the single largest category of patients seen in IRFs. There is widespread concern, therefore, that far fewer joint replacement patients will receive rehabilitation in IRFs.

Determinants of Outcomes of Lower Extremity Joint Replacement

The enforcement and revision of 75 percent rule was complicated by the dearth of clinical or health services research that explains where patients should go to receive the most appropriate post-acute care. In fact, little is understood about best practices regarding lower extremity joint replacement and the effectiveness of various rehabilitation options (Kane 1997, Kramer et al. 1997, DeJong et al. 2002, Jette and Keysor 2002). Research in this area struggles to address the problem of patient selection: in order to isolate the effects of PAC treatments, researchers need to account for variance attributable to factors including patient, clinical, demographic, and other unobservable items that vary across sites (Kane 1997).

The importance of observable predictive variables in the outcomes literature is mixed. Patient-related factors that have been correlated to total knee replacement outcomes include psychosocial variables, comorbidity, hospital volume, race, and preoperative functional status (Lingard et al. 2004; Heck et al. 1998; Sharma et al. 1996; Wasielewski et al. 1998; Fortin et al. 2002). The most frequently documented determinant of poor outcomes in total hip replacement is low procedural volume, either by individual surgeons, or by hospitals (Lavernia et al. 1995; Solomon et al. 2002; Taylor et al. 1997). In other cases, researchers have failed to find significant predictors (Kreder et al. 1998; Khuri 1999; Kane 2003). Other factors associated with LEJR outcomes included age, gender, race, medical comorbidity, abnormal laboratory values, postoperative deterioration of mental status, body mass index, low income, therapy intensity and rehabilitation duration (Braeken et al. 1997; Chen et al. 2002; Imamura and Black 1998; Jones et al. 2001; Lubitz et al. 1985; Mahomed et al. 2003; Poór et al., 1995; Weaver et al. 2003).

Outcomes of Post-Acute Care

There are no studies of outcomes of lower extremity joint replacement across post-acute care sites. The limited number of existing studies on PAC outcomes that have been able to account for patient selection focus generally on hospitalized Medicare patients, or subsamples of stroke or hip fracture patients. Previous studies comparing post-acute outcomes from IRFs, SNFs, and other post-acute locations for these populations have mixed results. Studies of stroke and hip fracture populations are also informative as they note how others have controlled for unobservable selection into PAC.

The importance of accounting for selection to different post-acute care settings is underscored in a study by Hadley et al. (2000). Using a Medicare Current Beneficiary Survey sample of hospitalized patients and instrumental variables analysis, their estimates suggested that home health care (HHC) users experienced greater improvements in functional status than nonusers. In contrast, estimation using only the observational data on HHC use implied that HHC users had poorer health outcomes.

The evidence on stroke rehabilitation favors the use of intensive rehabilitation, such as that provided in IRFs, for greater functional gain (Kane et al. 1998, 2000, Kramer et al. 1997), more frequent return to community (Deutsch 2003, Kane et al. 1998, Kramer et al. 1997), and lower death rates (Kane et al. 1996). Kane et al. (1996) found that stroke patients fared better when treated in IRFs; there was no substantial benefit for rehabilitative nursing home care over regular nursing home care. In addition, the mortality rates among stroke patients at each follow-up point were significantly higher for patients discharged to the two types of nursing homes than for patients sent to IRFs. Using predicted values of patient hospital discharge location as independent variables to control for selection, Kane et al. (1998) found that among stroke patients, those discharged to a nursing home had consistently higher adjusted mortality rates and were significantly more likely to be in a nursing home at each follow-up point than those discharged elsewhere. Comparing six-week post-discharge functional status, Kane et al. (2000) found that stroke patients discharged to formal home health care or rehabilitation regained a significant amount of function, while those discharged home without formal care showed only modest functional improvement and patients discharged to nursing homes experienced functional decline. Ang (2003) found that a specialized stroke unit, which combined acute and rehabilitative services, had benefits in reducing mortality, institutionalization, and LOS and improved functional status. However, it is important to note that the evidence in favor of intensive rehabilitation for stroke patients might not generalize to LEJR patients due to the substantial difference in clinical conditions and types of rehabilitative care needed for these two patient populations.

The evidence on hip fracture outcomes across post-acute sites is mixed. Some studies indicate that SNF is the best post-acute site for hip fracture patients. Deutsch et al. (2005) found that SNF-based subacute rehabilitation was less costly and discharge to community and functional outcomes were in most, but not all, instances similar or better than IRF-based rehabilitation for Medicare fee-for-service beneficiaries who had a recent hip fracture.

Other studies indicate that SNFs are not the best post-acute site for hip fracture patients. Kane et al. (1998) found that hip fracture patients discharged to nursing homes were more likely to be institutionalized than those sent to HHC, IRF or home and that hip fracture patients who received PAC in rehabilitation facilities or HHC had significantly more functional improvement compared with those discharged to nursing homes or to home without formal care. Without accounting for unobservable selection, Munin et al. (2005) found that patients in an IRF had significantly higher FIM™ motor scores than those in a SNF across time. A significantly higher percentage of IRF patients were discharged home after rehabilitation compared to SNF patients. Kane et al. (1996) found that for healthier hip fracture patients, the best functional outcome was associated with use of a rehabilitation facility and the worst was associated with rehabilitative nursing home. However, the same study found that for sicker hip fracture patients, the location at which post-hospital care was provided did not make a significant difference in terms of their functional recovery. In a later study, Kane et al. (1998) found that the mortality differences in hip fracture patients across settings were not as significant as those for stroke patients. Similarly, results from a study by Kramer et al. (1997) suggest that hip fracture patients admitted to rehabilitation hospitals do not differ from those admitted to nursing homes in their rates of return to the community or in the number of ADLs recovered to premorbid level.

In conclusion, there is a dearth of research on joint replacement outcomes across different sites of post-acute care, and the research on PAC outcomes in general is limited. The available evidence does indicate that some patients receive more therapy and have better outcomes in more intensive settings (e.g. in IRFs than in SNFs) although often at a higher cost. The evidence is less strong, however, for hip fracture, an orthopedic condition like joint replacement, than for stroke. These studies described above indicate that, after controlling for selection, type of post-acute setting can make a difference in outcomes for hip fracture and stroke patients. Our study of Medicare joint replacement patients will help to clarify the implications of the 75 percent rule for outcomes of LEJR.

IV. Data and Measures

Sample Studied

We have data on all elderly Medicare joint replacement patients discharged from hospitals between January 2002 and June 2003. Joint replacement was defined using the DRGs for joint replacement procedures (209, 471) minus those patients with a primary diagnosis of hip fracture and minus those with reattachment procedures 84.26, 84.27 and 84.28. Hip fracture patients are included in the 75% rule so their use of PAC is not affected by the regulation.

We defined post-acute location as the first post-acute care site used after discharge from an acute care hospital. We chose to use the first site because a large majority of acute discharges use only one site in their post-acute care episode. Ninety-three percent of all acute discharges use only one site of care. We considered post-acute care use to be IRF use, SNF use, or HHC that began within 30 days of discharge from acute care and was covered by Medicare.[2] We grouped care delivered in swing beds with SNF care. We also constructed files that contain data on sample patients' use and costs of care in long-term care hospitals (LTCHs). Each of these types of care was defined using Medicare provider numbers and/or claim types.

Patients who were readmitted to the hospital during the 30-day window were kept in the sample. Although Medicare rules allow SNF patients to delay entry for more than 30 days after their acute discharge (in order to gain enough strength to undertake rehabilitation) this did not greatly affect our analyses: 97.3 percent of SNF patients in our sample began SNF care within 30 days of discharge if they used it at all. Patients who died in the hospital or within 30 days of discharge were dropped from the sample because they were unlikely to be considered good candidates for rehabilitation. This excluded population was small – less than 1 percent of joint replacement patients died.[3] We

[2] We defined acute care hospitals using Medicare provider numbers. However, we dropped acute admissions that took place outside of the 50 states plus the District of Columbia and admissions to children's hospitals and psychiatric hospitals and units. We counted critical access hospitals (rural primary care hospitals) as acute care hospitals (provider numbers 1300 to 1399). We also excluded all patients residing in or receiving acute care in the state of Maryland as that state has its own hospital prospective payment system that makes it impossible to distinguish admissions to IRF facilities from acute admissions. In addition, care delivered in long term care hospitals (LTCHs) often qualifies as institutional PAC as well. We do not analyze LTCHs here, however, since there are relatively few of them. Less than 0.05 percent of Medicare patients discharged from acute care use these facilities, and the facilities do not all provide post-acute care. A few LTCHs, for example, serve a primarily psychiatric population (Liu et al. 2001).

[3] While this population is small, it could be argued that they are a key group of seriously ill patients. However, the data suggests that they are not good candidates for PAC as their rates of PAC use are considerably lower than those of the Medicare population as a whole over the time period examined.

excluded patients receiving custodial care in nursing homes because they are expected to return there and patients who are discharged to custodial nursing homes (defined using MDS data), because they are not candidates for rehabilitation. We also excluded patients discharged to LTCHs and those who receive rehabilitation in acute hospitals (under DRG 462) because our data suggests very low use and Medicare beneficiaries enrolled in HMOs within 4 months of their discharge because we do not have complete claims data for them. Patients were excluded if they were missing personal information, such as their zip code, or discharging hospital characteristics, such as disproportionate share. If a patient had more than one acute admission within 90 days for joint replacement, we only included the first stay in our dataset, and classified the second stay as a readmission. In total approximately three percent of the population was excluded for one or more of the reasons above.

Measures

We assembled, and included as independent variables in our models, a wide array of indicators of clinical, individual, discharging hospital, and PAC supply factors that might affect PAC choices.

Individual Predictors. We identified a number of patient-level characteristics hypothesized to affect use of PAC care and type of PAC site used. We included the age of the beneficiary and their age squared to capture a non-linear relationship between outcome and age should one exist. We also included gender, race and place of residence (defined as a MSA, an area adjacent to a MSA, or rural area/not adjacent to an MSA) in our analyses. We also include an interaction between gender and age, and this interaction term squared. All of these patient-level predictors were created using fields on the inpatient claims. In addition, we used the Medicare Denominator file to create indicators for whether patients were receiving Medicaid at the time of their acute admission or within 4 months of discharge. (Those who went on Medicaid soon after discharge were presumed to have been income-eligible for coverage, but not yet enrolled.)

Clinical Predictors. To capture the complexity of patients at the time of hospital discharge we included a large set of comorbidities and complications tailored to our joint replacement patients. These were derived from diagnoses on the hospital discharge records. The comorbidities used in our analyses were the chronic conditions identified by Iezzoni et al. (1994) as conditions that are nearly always present prior to hospital admission and hence are extremely unlikely to represent complications arising during the hospitalization. These conditions included primary cancer with poor prognosis, metastatic cancer, chronic pulmonary disease, coronary artery disease, congestive heart failure, peripheral vascular disease, severe chronic liver disease, diabetes mellitus with and without end-organ damage, chronic renal failure, nutritional deficiencies, dementia, and functional impairment.

The second type of case mix variable was complications that were likely to have arisen during the hospital. To develop this list, we adapted the list of complications developed by Iezzoni et al. (1994). From that list, we kept only those complications that were likely to have a continued effect after hospital discharge, and therefore to potentially influence the choice of site for post-acute care (e.g., we excluded transient metabolic derangements and side effects of medications). In addition, we augmented the list to include some important complications for the Medicare population that had been omitted from Iezzoni's list. The resulting list of complications included post-operative pulmonary compromise, post-operative gastrointestinal hemorrhage, cellulitis or decubitus ulcer, septicemia, pneumonia, mechanical complications due to a device, implant, or graft, shock or arrest in the hospital, post-operative acute myocardial infarction (AMI), post-operative cardiac abnormalities other than AMI, procedure-related perforation or laceration, venous thrombosis and pulmonary embolism, acute renal failure, miscellaneous complications, delirium, dementia, and stroke.

We created indicators of the type of replacement the patient received, such as a hip or knee replacement, a total replacement, a partial replacement, and/or a revision of a previous joint replacement, and whether a bilateral replacement took place (Beeuwkes Buntin et al. 2005).

Characteristics of Discharging Hospitals. Patterns of care and approaches to discharge planning in the acute care hospital can influence the PAC use of patients. Accordingly, we included a number of covariates to capture the orientation of acute care hospitals. They include size (average daily census or ADC), teaching status (resident to ADC ratio), ownership status (government, private non-profit, or for-profit), Medicare patient percentage, case-mix index of the hospital, and low-income patient percentage. We also included a measure of the HMO penetration rate. These measures were created using cost report and provider of service data available from the CMS website and the area resource file.

PAC Availability. We defined availability from a patient-specific perspective based on how close IRFs and SNFs were to patients' homes and how many of each type of facility were within reasonable distances of patients' homes. To construct our measures, we used patient and provider zip code information to measure the distance traveled from patients' residences to IRFs and SNFs. We used geocoding software to calculate distances from the midpoint of each beneficiary's zip code to the midpoint of the closest provider zip code.

We created two measures of the availability of PAC. The first captures the distance from the patient to the closest provider (separate measures are created for closest IRF and closest SNF). Both the distance to the closest and the distance squared are included, since the effects of distance on PAC choice are likely diminishing as distances become large. These variables measure how accessible the provider type is in terms of proximity. The second measure includes the number of PAC providers of each type within a given radius around the patient's home. We calculated these radii for joint replacement patients by area type, and defined the radii using the 90th percentile of the distance traveled to that type of provider by beneficiaries living in that type of area; the 90th percentile was chosen since it reflected a generous definition of the market area, but was not biased by the care patterns of patients who might be receiving care far from home due to holidays or other reasons. We also created indicators for areas without any of a given type of provider as the lack of providers would have a strong negative effect on the use of that type of PAC.[4]

Outcomes. We examined descriptive statistics on five health outcomes and modeled two outcomes. We looked at rehospitalization within 60 days and 120 days

[4] We calculated the correlation between our measures of PAC supply and more typical measures of supply that take into account only the number of providers within patients' counties. As expected, the measures of numbers of providers were positively correlated. However, they were strongly correlated only within MSAs. In addition, our radius-based measures had higher coefficients of variation, suggesting that they are more sensitive to variations in availability.

descriptively using Medicare claim files. We used the Minimum Data Set for nursing home residents (MDS) to identify those patients residing in a custodial nursing home at 60 and 120 days. The MDS file contains assessments of all residents in nursing homes in the U.S. regardless of the payer. Each record in the MDS is an assessment with a date—assessments are performed at various times in the resident's stay according to national regulation. The assessment schedule mandates that assessments will be performed for a nursing facility resident at admission, quarterly, and annually, whenever the resident experiences a significant change in status, and whenever the facility identifies a significant error in a prior assessment. Using these assessment records, we created an array for each patient with their location on each day. If there are two assessments that are less than 95 days apart, we assume that this patient was in the nursing home for the entire period between the assessments. We chose the 95-day threshold because nursing homes are mandated to complete an assessment quarterly at a minimum (every 90 days), and then allowed a 5-day tolerance.

To examine the validity of these MDS-based outcomes measures we looked at whether those we found to be institutionalized at these intervals were in fact highly unlikely to be community residents. Of those discharged from an IRF, 30 percent of those still in the nursing home at day 180 went there without going home first. Only 0.38 percent of those at home on day 180 were discharged to custodial care first. Of those discharged from a SNF, 60 percent of those in the nursing home at day 180 went there without going home first, while 3.5 percent of those at home on day 180 were discharged to a custodial nursing home. These figures indicate that our measures are valid indicators of nursing home residence.

We created an indicator for patients who died within 60 and 120 days of their hospital discharge using Medpar data. We then combined these two variables (institutalization and mortality) into a composite measure since just using the variable for the populations of survivors would result in a biased subsample. We used this composite measure of institutalization or mortality and the mortality indicator in our models of health outcomes. Additionally, we created a variable that indicated that the beneficiary was independent in the community—not in a nursing home, not dead and not using any post-acute care (including home health care) as an indicator for a "positive" outcome. (We could not, however, examine outpatient or hospice care use in creating this measure.)

<u>Payments and Length of Stay.</u> Using the home health, skilled nursing, and inpatient rehabilitation standard analytic files and hospital claims, we built length of stay and payment variables for each site of care for each beneficiary with an acute admission for lower-extremity joint replacement in 2002 or 2003. We wage-adjusted the acute payments using the impact file for post-reclassified wage index data for PPS hospitals and post-acute payments using the MSAX file for the pre-reclassified wage index, which is a longitudinal file at the MSA level. We then created summary variables of total post-acute length of stay and payments, and total length of stay and payments (including the initial acute stay).

<u>Functional Status.</u> We created a measure of functional status similar to the Barthel Index (Mahoney and Barthel 1965) and mapped it to the MDS and the IRF patient assessment instrument (PAI) using methods analogous to those described by Johnson et al. (2001). This is a particularly daunting undertaking because the assessment

instruments ask differing questions and the patients are assessed at different times in their post-acute stay. For example, to evaluate the patient's ability to walk, the MDS has two separate items for locomotion. The first is "Walk in Corridor (how resident walks in corridor on unit)" rated on a scale from 0-4 or did not occur. The second item is "Modes of Locomotion", where one is to "check all that apply" among cane/walker/crutch, wheeled self, other person wheeled, wheelchair primary mode of locomotion. The IRF PAI has one item for locomotion—split into walk, wheelchair, or both, and is scored from 0-7. In addition to these differences, the patient only has to be evaluated once in the first 5 days in a SNF, while the IRF PAI is completed within 72 hours of admission. The IRF PAI is also completed at discharge, while the SNF MDS is only completed at the 14th day if the patient has a length of stay greater than 14 days.

Because of the differences between the instruments and the timing of assessments, we also looked at the individual walking and transfer items and created a dichotomous variable that indicates whether the beneficiary can walk or transfer on their own (or with supervision). We examine these variables descriptively below, but they are not included in our models because we felt they were too inconsistently measured across IRFs and SNFs to be treated formally as outcomes.

V. Methods

Descriptive Analysis

We conducted descriptive analyses of LEJR patients' characteristics, use of PAC, costs, and outcomes. We examined how costs and outcomes vary by the first post-acute setting used following acute hospital discharge as described above.

Standard Multivariate Analysis

After conducting the descriptive analyses we used multivariate regression to estimate how the site of PAC care affected outcomes measures. The multivariate analysis allows us to control for *observable* differences in the patient population in each site of care that might confound our estimates of the effect of site of PAC care on outcomes. In particular, all our models control for the individual predictors, clinical predictors and characteristics of discharging hospitals described in the previous section.

For this analysis, we looked at whether the patient's first site of post-acute care was an IRF or a SNF. Outcomes of these two groups of patients were compared to the outcomes of a reference group who did not receive PAC in a SNF or IRF within 30 days of discharge from acute care. A significant proportion (63%) of patients in the reference group received home health care. It is also likely that some patients in the reference group received outpatient rehabilitation care. However, since we did not have data on outpatient care we could not measure the use of outpatient care by these patients.

As described in the previous section, we used two measures of health outcomes for this analysis – (1) a composite measure of mortality and institutionalization that indicated whether the patient had died or was receiving care in an institutional setting 120 days after discharge from acute care; (2) whether the patient died within 120 days of discharge from acute care. Because both our outcome measures are binary we used probit models to model each of the outcomes. While probit models account for the binary nature of the outcome variables, it is difficult to directly interpret the magnitude of coefficient estimates from these models. Thus, we report the "marginal effect" of each site of PAC care on the outcome measures for a person with average characteristics. The marginal effect for a particular site of care measures the extent to which receiving care in that site increases (or decreases) the probability of having the outcome compared to patients in the reference group.

Finally, we also model how the site of PAC affects Medicare payments for the episode of care. We used two measures of Medicare payments – (1) total post-acute care payments starting with acute care discharge and ending 120 days after discharge from acute care; and (2) total Medicare payments for acute and post-acute care starting with the acute care admission and ending 120 days after discharge from acute care. Since payments are measured on a continuous scale, we used ordinary least squares (OLS) regression to model payments.

Instrumental Variables Analysis

In addition to confounding due to selection on observables, which the probit and least squares models for health outcomes and payments, respectively, take into account, it is likely that there is confounding due to selection on unobservable characteristics of the patients. Instrumental variables (IV) methods can be used to purge the estimates of such confounding due to unobservable characteristics. The linear instrumental variables model is a widely used and powerful tool in such contexts. Although it was developed for models of continuous outcomes and endogenous regressors, it has been shown to work well even when the outcome and/or endogenous regressor is binary (see, e.g., Angrist, 2001). Under appropriate conditions IV methods provide consistent estimates without strong distributional assumptions and are computationally simple. For nonlinear and limited dependent variable models in general, however, the linear IV model may either be inappropriate or not work well in practice. Specifically, in our case, although the outcomes of interest are either binary or linear, the endogenous regressors (dummy variables for IRF and SNF) are from a multinomial distribution. A linear IV model would treat the endogenous regressors as if they were unrelated, which is not true because a patient goes to an IRF, SNF, or neither upon acute discharge.

Instead, we formulate a nonlinear instrumental variables model using latent factors to account for selection on unobservables.[5] Our model respects the multinomial nature of the endogenous regressors as well as the binary nature of the health outcome. Specifically, we assume that the endogenous regressors have a multinomial logit form, while the health outcome and payments have probit and normal (linear) forms respectively. Then, latent factors are incorporated into the equations to allow for unobserved influences on care choice to affect outcomes and their joint distribution specified. Such models have been developed in Deb and Trivedi (2004).

The main computational problem is that the joint distribution, which involves a multidimensional integral, does not have a closed form solution. This difficulty can be addressed using simulation-based estimation (Gourieroux and Monfort, 1996). Using normally distributed random draws for the latent variables, a simulated likelihood function for the data is defined and its parameters estimated using a Maximum Simulated Likelihood Estimator. Because of the complexity of our model and the large sample size, standard simulation methods are quite slow. Therefore, we adapt an acceleration

[5] The equations can be found in Appendix I.

technique that uses quasi-random draws based on Halton sequences (Bhat, 2001; Train, 2002). Additional details on estimation and simulation are reported in Deb and Trivedi (2004).

Validity of Instruments

We use the measures of PAC availability described in Section III as instruments. We anticipate that these PAC factors are uncorrelated with beneficiaries' clinical needs since seniors are unlikely to choose where to live based on proximity to IRFs and SNFs. We use the instruments to predict use of IRFs and SNFs, and thus to infer the effect on outcomes of a marginal patient (*i.e.,* a patient whose choice among IRF, SNF, or neither site would be affected by our instruments) going to an IRF or a SNF. We use two sets of instruments in the analyses. The first set of instruments captures the distance from the patient to the closest provider and includes distance to closest SNF, distance to closest IRF, distance to closest SNF squared, and distance to closest IRF squared. The second set of instruments measures the number of PAC providers of each type within a given radius around the patient's home. Instruments in this set include number of SNFs within travel radius, number of IRFs within travel radius, an indicator for no SNFs in travel radius, and an indicator for no IRFs in travel radius

As in all instrumental variable based models, the validity of our results rests on the validity of our instruments. Valid instruments must satisfy two properties. First, they should be strongly correlated with the endogenous variable, i.e. our measures of PAC availability should be strong predictors of the PAC site used. Second, the instruments should only affect outcomes through their effect on the choice of post-acute care and they should be uncorrelated with unobserved factors that affect outcomes. Our instruments pass the first test of instrument validity convincingly. The descriptive statistics in Table 1 clearly show that our PAC availability measures for both SNFs and IRFs are strong predictors of SNF and IRF use respectively. This result is also confirmed in multivariate analysis that controls for patient and discharging hospital characteristics. In all our multinomial logit models of the choice of site of PAC care the PAC availability measures for both SNFs and IRFs are highly statistically significant (p value < 0.001) and are important predictors of the site of care. Our prior work (Beeuwkes Buntin et al., 2005) also provides evidence that the relative supply of and distance to IRFs and SNFs in the area in which a beneficiary lives are important and strong predictors of the site of post-acute care.

The second condition is trickier. As noted, instrumental variable estimates are unbiased if and only if the instruments only affect outcomes through their effect on the choice of post-acute care and they are uncorrelated with unobserved factors that affect outcomes. Unfortunately, this assumption cannot be tested directly. Thus, to address this issue we examined indirect evidence for the validity of our instruments and considered possible reasons why they might not be valid.

An important concern is that our instruments might be invalid if they are correlated with *unobserved* determinants of our outcomes. If this were the case, then our instruments would influence outcomes independent of their effect on the choice of site of PAC care. As one test for this, we estimate whether our instruments are correlated with observable patient and clinical predictors. If our instruments are correlated with observable patient characteristics then they might also be correlated with unobservable patient characteristics that determine outcomes. To implement this test we estimate OLS models of PAC availability as a function of patient and clinical predictors. A high R-square from these regressions would suggest that our patient and clinical characteristics are correlated with our instruments and are important predictors of availability of PAC. However, our results show that the R-squares of the regressions for each of our 4 measures of PAC availability (distance to closest SNF, distance to closest IRF, number of SNFs within 90th percentile travel radius, number of IRFs within 90th percentile travel radius) ranged from 0.004 to 0.008. The low R-squares from these regressions clearly suggest that markets that vary substantially in their availability of PAC do not vary much in their patient populations.

Our instruments could also be correlated with unobserved provider attributes that influence outcomes, such as quality of care. This could happen, for instance, if IRFs and SNFs in more competitive markets provide higher quality. The problem is that our instruments, which essentially measure the geographical density of IRFs and SNFs, capture dimensions of competition. Again, we cannot test this directly, but we did develop two indirect tests.

One indirect way to judge the importance of unobservable differences in patient characteristics or provider quality across markets is to test the extent to which variation in our outcomes is generated by market level heterogeneity that is independent of the variation in PAC availability across markets. To implement this test we estimate 2 models for each of our health outcome measures. The first model is fully non-parametric model of the outcome measures with 604 dummy variables for each MSA (or market) with at least 100 patients in the sample and our set of patient and clinical predictors. The second model is a parsimonious model of outcomes that only includes our 8 instruments, patient and clinical predictors. If market level heterogeneity in patient populations is important then the fully non-parametric model will have a much higher R-square (predictive power) compared to the parsimonious model with only PAC availability measures. The results from this test also confirm that heterogeneity across markets in patient attributes or provider quality is not an important threat to the validity of our instruments. The R-squares from the fully non-parametric model were only marginally higher despite the inclusion of 604 MSA dummies in the model. For example, the R-square for the fully non-parametric model was 0.0715 for our Mortality/Institutalization outcome and the R-square for the parsimonious model was marginally lower at 0.0698.

In the second indirect test of instrument validity, we checked the robustness of our results to the inclusion or exclusion of certain sets of instruments. This test is in the spirit of the Hausman over-identification test and is based on the principle that if all our instruments are valid then the estimates obtained by using only a subset of instruments should differ only as a result of sampling error (Hausman, 1978). Thus, for this test we estimated two different sets of models. The first set of models only used the distance measures as the instruments -- distance to closest IRF, distance to closest SNF, distance to closest IRF squared, and distance to closest SNF squared. The second set of models only used the radius measures as instruments -- number of IRFs in travel radius, number of SNFs in travel radius, no IRFs in travel radius, no SNFs in travel radius. The results from both these sets of models were virtually identical to the model that used both distance and radius measures as instruments. Thus, these results also suggest that our instruments are valid.

We underscore that our tests for the validity of our instruments are indirect tests, as there are no direct and definitive tests. These tests suggest that our instruments are valid and, therefore, that our instrumental variable estimates are unbiased. Nonetheless, we cannot rule out the possibility that we have failed to detect a problem with our instruments. The consequence would be that our instrumental variable estimates are not fully purged of selection effects. We discuss this further in the conclusion section.

VI. Results

Table 1 shows descriptive statistics for our patient population by first post-acute care location. Approximately 30 percent of the sample used SNF care, 35 percent used IRF care, and the remainder returned home (either with home health care or without any Medicare-paid post-acute care). The asterisks on these tables indicate a statistically significant difference between the IRF and SNF population, and the asterisk is placed next to the higher of the means. These data highlight the differences in patient populations across different sites of care, and clearly demonstrate why it is crucial to worry about selection when we examine outcomes. In particular, the first set of characteristics show that SNF patients are on average older and sicker, and there is some evidence that they have lower socioeconomic status. Specifically, patients who went to SNFs were on average 1.4 years older than those who went to IRFs and 3.6 years older than those who went home. Those who went to a SNF were also more likely to be Medicaid beneficiaries than those who went to an IRF or home. Those who went to an IRF were more likely to live in an MSA. Patients in SNFs have more complications and comorbidities on average than those going to IRFs or home.

There are also important differences in procedures performed and discharging hospital characteristics. More hip replacement patients go to SNFs for post-acute care, while knee replacements tend to use IRFs or go home. On average, IRF patients come from larger discharging hospitals with a higher case mix and they tend to use teaching hospitals more.

Prior research has found that PAC availability is related to choice of post-acute site (Beeuwkes Buntin et al. 2005). The descriptive statistics show that those who go to an IRF have, on average, more IRFs within their travel radius, while those who go to SNFs have more SNFs within their travel radius. IRF patients have a shorter travel distance to both the closest IRF and the closest SNF. This is probably due to IRF patients living in more urban areas.

Table 2 displays the mean values of our outcome measures. Functional status is only measured for our IRF and SNF populations because the patients who go home without care are not assessed. IRF patients are assessed at admission and discharge, while SNF patients are assessed at 5 days and 14 days (if they are still in the SNF). On average, SNF patients have a higher functional status score (indicating that they are more able) at the beginning of their stay (at admission or 5 days), and a lower functional score toward the end of their stay (at discharge or 14 days) than IRF patients. Scores in both locations increase during the stay, but descriptively the IRF patients gain more function. This trend holds when we compare only the populations who have a stay 14 days or longer. This trend also holds when we look at individual functional items, such as ability to walk or transfer independently. While we cannot compare improvement in functional status directly given the different assessment instruments and timeframes, there is clearly a greater functional gain from admission to discharge among IRF patients than among SNF patients over a similar time period.

The health outcomes we looked at descriptively include rehospitalization, institutionalization, mortality, and independence in community. We looked at these variables at 60 and 120 days and looked at independent in community out to 180 days. IRF patients are the most likely to be rehospitalized, by both 60 and 120 days. SNF patients are most likely to die or be institutionalized. Patients returning home after their hospital stay are, on average, more likely to be independent in the community at all intervals, while IRF patients are more likely than SNF patients to be independent. As seen from the table, the means are very low for institutalization and mortality. For example, only 0.8 percent of those who have IRF as their first site of PAC are dead or institutionalized at 120 days. Because joint replacement is an elective surgery, the population under examination is very healthy. Of course, these descriptive differences in outcomes are in large part, if not fully, due to differences in patient populations. Our multivariate analyses shed light on the importance of selection of different types of patients into SNFs and IRFs in determining outcomes.

We also looked at length of stay and payments for 60 day and 120 day "episodes" of care. Those who go to SNFs tend to have the largest number of post-acute and total (acute and post-acute) days of care during both intervals, while costing less than IRF patients. As Table 2 shows, patients who use IRF care do not use much SNF care, and vice versa. IRF and SNF patients both have a high rate of transfer to HHC. However, SNFs discharge patients to HHC more often than IRFs do. The acute hospital payments are higher for IRF patients. We have adjusted these payments with Medicare wage indices so these higher payments are probably due to the teaching and disproportionate share adjustments of the hospitals from which IRF patients are discharged.

Standard Multivariate Results

Table 3 reports the descriptive results and results from two different regression models. The first set of results "Unadjusted Models" reports the marginal effects for health outcomes and Medicare payments for patients whose first site of PAC was an IRF or SNF as compared to the reference group that received no institutional care. The second set of results, "Naïve Models", report the marginal effects for the multivariate analysis that controls for observable patient and hospital characteristics but does not control for selection into site of PAC based on unobservables. Finally, the results in the last set of columns, "IV models", report the marginal effects from our instrumental variables models. As described earlier, the goal of these models is to control for selection in site of care based both on observable and unobservable characteristics.[6]

Health Outcomes

Overall, the results show that patients whose first site of care is an IRF or SNF (compared to patients in the reference group who get home health care, other outpatient rehabilitation care, or no care) are more likely to have worse outcomes as measured by higher rates of mortality or care in an institutional setting 120 days after discharge from acute care. However, the pattern of findings as we move from the unadjusted analyses to

[6] The full set of regression results can be found in Appendix II.

the IV models offers an excellent illustration of the need to control for selection into different PAC sites and to consider whether even our IV models succeed in controlling fully for selection.

As shown, in the unadjusted model IRF patients are 0.6 percentage points more likely to be dead or institutionalized at post-discharge day 120 as compared to patients in the reference category. Controlling for observable differences in patient and hospital characteristics (the naïve model) reduces this marginal effect of IRF care by a third, to a difference of 0.43 percentage points. Accounting for patient selection on both observable and unobservable characteristics further reduces the IRF marginal effect to only 0.18 percentage points, and this effect is only significantly different from zero at the 96% confidence level.

A similar pattern emerges for the marginal effect of SNF use on the probability of death or institutionalization at day 120. The unadjusted model shows that SNF patients are 2.7 percentage points more likely to be to be dead or institutionalized at post-discharge day 120 as compared to patients in the reference category. The difference is reduced to 1.2 percentage points in the naïve model that controls for observable characteristics and to 0.46 percentage points in the IV model. The SNF effect in the IV model is statistically significant at the 99% confidence level. Although the marginal effects of SNFs and IRFs are small in absolute terms they are large relative to the rate of mortality or institutionalization experienced by the reference group that did not receive PAC in a SNF or IRF within 30 days of discharge from acute care.

Notably, the results from the mortality only models show that after controlling for observable and unobservable patient and hospital characteristics (the IV model) there are no statistically significant differences in mortality rates across patients in different sites of post-acute care. Thus the differences in mortality rates observed in the raw data are driven by differences in patient population.

To summarize, our findings for health outcomes indicate that there is a great deal of selection into different sites of PAC based on patient characteristics. Patients who use IRF care are at higher risk of death or long-term institutionalization than those who use no institutional PAC, and those who use SNF care are at higher risk still. An important problem in assessing the causal effect of PAC on health outcomes is that this selection is based on both characteristics we observe and those we cannot observe.

To control for both observable and unobservable patient differences, we estimated IV models. These analyses found no difference in mortality across PAC sites, but they did find that patients who used IRF or SNF care were slightly more likely than those in the reference group to be institutionalized at 120 days post-discharge. Thus, the marginal effects imply a relative risk ratio of 1.6 for IRFs and 2.5 for SNFs. In other words, the results from the IV model indicate that receiving post-acute care in an IRF increases the probability of death or institutionalization by 60% and seeking care in a SNF increases this probability by 150% compared with being sent home without institutional PAC. We conducted several indirect tests to assess the validity of our instruments and they seemed to perform well. Nonetheless, it is possible that our IV models did not fully purge our results of selection effects. For one, our tests of instrument validity are only indirect and suggestive; they are not conclusive. Additionally, even with valid instruments, IV estimates may retain some bias in the same direction as naïve estimates in finite samples (Staiger and Stock, 1997).

Medicare Payments

In general, the results from the models show that episodes of post-acute care in an IRF or SNF are much more expensive (reflecting higher Medicare payments) than episodes of care for patients in the reference category. The results also show that Medicare payments for episodes of care beginning in IRFs are much higher than episodes of care beginning in a SNF, even after controlling for patient and discharging hospital characteristics. For example, the results from the IV model that accounts for selection both on observable and unobservable patient characteristics show that total Medicare payments (for 120 day episodes of care) for IRF and SNF patients were $8,023 and $3,578 respectively higher than Medicare payments for patients in the reference group. The results are similar when one compares total Medicare payments for post-acute care. Finally, these results also highlight the importance of controlling for patient selection, although controlling for selection had a smaller effect in the payment models compared to the outcome models.

VII. Conclusions

Our results indicate that there are differences in costs and possibly in outcomes across PAC sites for LEJR patients. Our models that control for both observable and unobservable selection suggest that IRF and SNF patients have a higher probability of being institutionalized 120 days post-discharge than patients who receive no institutional PAC. In particular, the results indicate that compared to patients at home, patients in IRFs and SNFs are more likely to be to be dead or institutionalized at post-discharge day 120 by 0.18 percentage points and 0.46 percentage points respectively. Notably, neither IRFs nor SNFs have a significant effect on mortality alone, implying that the effect on outcomes is operating exclusively through institutionalization. We reached similar conclusions about Medicare payments across sites of care. IRF payments for episodes following a LEJR were the highest, controlling for observable and unobservable characteristics, SNF patient episode payments were lower, and payments for patients not discharged to institutional PAC were the lowest.

It is important in evaluating these findings to understand a key limitation of studies of health outcomes based on observational data: controlling fully for selection is extremely difficult. Our best estimates of the causal effect of PAC on outcomes are the IV models, but we cannot rule out the possibility that some selection remains in these estimates. Outcomes depend on many factors, including patients' physical and cognitive abilities, underlying medical diseases, sensory and emotional factors, willingness to participate in care, and supportive environments. No risk-adjustment approach can control for every factor affecting outcomes of care (Iezzoni, 2004). While our choice of instrumental variables was carefully considered to address this problem, our estimates could be biased if our instruments are invalid.

Another limitation of the study is that the outcomes we analyzed are not the ideal outcomes for LEJR patients. We would have preferred to examine functional status and changes therein, but we did not have the necessary data. Death and institutionalization at 120 days are imperfect proxies for functional decline and are likely to be less closely related than functional status to the surgical procedure and the rehabilitation process. In addition, our outcome measures do not capture other dimensions of quality of life. The evidence from our unadjusted functional measures suggests that patients going to IRFs and SNFs experience a short-term increase in functional status, with IRF patients beginning their stays with a lower level of functioning and achieving a higher level of functioning than SNF patients over a similar period of time.

Finally, we underscore that our results do not apply to all patients who use IRFs or SNFs. Rather, our IV models show the effects of IRF and SNF use for *marginal* patients. In this context, marginal patients are those whose decision to use IRF or SNF is swayed by the proximity and availability of these PAC sites. Thus our results apply to patients for whom, in a sense, the clinical decision is gray. They do not apply to patients who are ideal candidates for an IRF or who clearly require SNF care. Rather than being a limitation of our analysis, our focus on the marginal patient is an asset from a policy decision-making perspective since it is precisely these patients who will likely be affected by the reduced accessibility of IRF care as the 75 percent rule is enforced.

Our analyses of costs have limitations as well. We have not captured the costs of physician, outpatient and hospice care. If patients not using institutional PAC rely more heavily on those types of care, then our findings overstate the degree to which IRF and SNF episodes of care are more expensive. If patients in IRFs and SNFs are using these services after their stay, our findings could understate costs for these patients. However, we do include costs of home health care, which is used at comparable rates by patients regardless of discharge destination. It seems reasonable to believe that use of outpatient and hospice care is likewise comparable across all categories of patients (i.e., those use institutional PAC and those who do not).

What does this say about the wisdom of the 75 percent case-mix rule for IRFs? If, as CMS argued during its rulemaking process, the effect of the revised regulation will be to shift LEJR patients from IRFs to SNFs then Medicare payments will likely be reduced by the enforcement of the 75 percent rule. However, our findings indicate while expenditures would be reduced, the outcome measure used here indicates that there is a higher risk of institutionalization if patients are switched from IRFs to SNFs.

However, in order to fully assess the impact of the 75 percent rule, we would need three additional types of information. First, we would ideally measure real resource use across sites of care rather than measuring only Medicare payments. Second, we would need a method for evaluating the trade-off between better outcomes and higher costs. Finally, we would need better measures of outcomes, including a measure of functional status that was captured consistently across all discharge settings.

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Table 1: Patient Characteristics by PAC Site
Lower Extremity Joint Replacement Patients
January 2002 to June 2003

First Site of Post-Acute Care	No IRF or SNF Mean	No IRF or SNF Standard Deviation	IRF Mean	IRF Standard Deviation	SNF Mean	SNF Standard Deviation
Number of Observations	148,558		148,874		127,719	
Percent to Post-Acute Setting	34.94%		35.02%		30.04%	
Demographics						
Female	0.543	0.498	0.702	0.457	0.722 **	0.448
White	0.942	0.234	0.899	0.302	0.933 **	0.249
Black	0.033	0.178	0.068 **	0.251	0.041	0.198
Hispanic	0.007	0.080	0.012 **	0.110	0.008	0.090
Age	72.740	5.394	74.976	6.012	76.344 **	6.353
Beneficiary is covered by Medicaid	0.052	0.223	0.092	0.288	0.101 **	0.301
Lives in an MSA	0.651	0.477	0.777 **	0.416	0.670	0.470
Lives adjacent to an MSA	0.182	0.386	0.126	0.332	0.181 **	0.385
Complications						
Post-operative pulmonary compromise	0.003	0.056	0.005	0.074	0.008 **	0.087
Post-operative GI hemorrhage or ulceration	0.002	0.043	0.002	0.046	0.003 **	0.057
Cellulitis or decubitus ulcer	0.003	0.057	0.005	0.067	0.008 **	0.091
Septicemia	0.000	0.016	0.000	0.018	0.001 **	0.027
Mechanical complications due to device or implant	0.009	0.095	0.012	0.107	0.017 **	0.128
Miscellaneous complications	0.013	0.112	0.011	0.103	0.016 **	0.124
Shock or cardiorespiratory arrest	0.001	0.027	0.001	0.032	0.002 **	0.041
Post-op heart attack (AMI)	0.003	0.051	0.004	0.065	0.006 **	0.076
Post-op cardiac abnormalities other than AMI	0.001	0.023	0.001	0.023	0.001	0.027
Procedure-related laceration or perforation	0.001	0.033	0.001	0.033	0.001	0.034
Venous thrombosis or pulmonary embolism	0.005	0.070	0.007 **	0.085	0.006	0.077
Iatrogenic complications	0.034	0.182	0.040	0.196	0.047 **	0.212
Sentinel Events	0.001	0.030	0.001	0.031	0.001 *	0.035
Comorbidities						
Acute renal failure	0.003	0.057	0.007	0.082	0.008 **	0.091
Delirium	0.007	0.086	0.014	0.119	0.020 **	0.139
Cancer with a Poor Prognosis	0.003	0.053	0.003	0.056	0.003	0.059
Metastatic Cancer	0.001	0.026	0.001	0.028	0.001 *	0.034
Chronic Pulmonary Disease	0.091	0.288	0.112	0.315	0.118 **	0.323
Coronary Artery Disease	0.155	0.362	0.178 *	0.382	0.173	0.378
Congestive Heart Failure	0.034	0.181	0.058	0.234	0.071 **	0.257
Peripheral Vascular Disease	0.016	0.125	0.021	0.142	0.022 *	0.147
Severe Chronic Liver Disease	0.001	0.035	0.002	0.040	0.002	0.042
Diabetes with End Organ Damage	0.006	0.077	0.010	0.101	0.011	0.103
Chronic Renal Failure	0.001	0.035	0.002	0.040	0.002 **	0.049
Nutritional Deficiencies	0.001	0.031	0.002	0.046	0.004 **	0.062
Dementia	0.005	0.072	0.009	0.097	0.023 **	0.151
Functional Impairment	0.005	0.068	0.011	0.103	0.010	0.102
Diabetes without End Organ Damage	0.122	0.328	0.152	0.359	0.151	0.358
Pneumonia	0.006	0.074	0.008	0.087	0.012 **	0.110
Stroke	0.000	0.022	0.002	0.044	0.002	0.047

Notes: Patients who were in a custodial nursing home before their acute stay, in a custodial nursing home after their acute stay, who used acute rehab (DRG 462), used long term care hospitals, or died in the first 30 days after their acute discharge are excluded from this analysis. This excludes less than 3% of our sample.
A double asterisk (**) indicates a significant t-test for difference between IRF and SNF values at the 0.0001 level.
A single asterisk (*) indicates a significant difference at the 0.05 level. Asterisk is placed next to the higher of the two means.

Table 1: Patient Characteristics by PAC Site (continued)
Lower Extremity Joint Replacement Patients
January 2002 to June 2003

First Site of Post-Acute Care	No IRF or SNF		IRF		SNF	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Type of Replacement						
Hip Replacement	0.312	0.463	0.361	0.480	0.400 **	0.490
Total Hip Replacement	0.258	0.438	0.301	0.459	0.310 **	0.463
Partial Hip Replacement	0.006	0.078	0.013	0.113	0.027 **	0.163
Hip Revision	0.048	0.214	0.048	0.214	0.063 **	0.243
Knee Replacement	0.685	0.465	0.639 **	0.480	0.600	0.490
Total Knee Replacement	0.625	0.484	0.600 **	0.490	0.558	0.497
Knee Revision	0.061	0.239	0.040	0.196	0.043 *	0.202
Bilateral Procedure	0.018	0.134	0.062 **	0.241	0.040	0.195
Discharging Hospital Characteristics						
Non-Profit Hospital	0.779	0.415	0.756	0.429	0.793 **	0.405
Government Hospital	0.100	0.300	0.086	0.281	0.097 **	0.296
Average Daily Census of Hospital	203.626	171.514	234.717 **	181.666	190.566	177.802
Resident to ADC ratio of Hospital	0.118	0.220	0.144 **	0.246	0.110	0.214
Percentage of Low Income Patients	0.123	0.080	0.125 **	0.090	0.121	0.077
% Medicare days	0.472	0.121	0.471	0.118	0.485 **	0.119
Case Mix Index of Hospital	1.532	0.240	1.548 **	0.235	1.469	0.245
HMO Penetration Rate	8.609	12.278	10.090	12.399	10.307 *	12.915
IRFs within travel radius	10.573	12.264	12.769 **	13.240	11.331	13.310
SNFs within travel radius	38.848	42.869	43.383	45.097	46.156 **	48.029
No IRFs within travel radius	0.032	0.176	0.013	0.115	0.031 *	0.172
No SNFs within travel radius	0.001	0.036	0.001 **	0.033	0.001	0.027
Distance to nearest SNF (miles)	2.586	5.421	1.909	4.467	2.033 **	4.590
Distance to nearest IRF (miles)	17.535	22.714	10.842	23.800	17.831 **	21.554
Distance to nearest SNF squared (miles)	36.076	262.525	23.601	214.603	25.198	219.340
Distance to nearest IRF squared (miles)	823.391	5,579.52	684.006	12,790.92	782.509 **	4,389.06

Notes: Patients who were in a custodial nursing home before their acute stay, in a custodial nursing home after their acute stay, who used acute rehab (DRG 462), used long term care hospitals, or died in the first 30 days after their acute discharge are excluded from this analysis. This excludes less than 3% of our sample.
A double asterisk (**) indicates a significant t-test for difference between IRF and SNF values at the 0.0001 level.
A single asterisk (*) indicates a significant difference at the 0.05 level. Asterisk is placed next to the higher of the two means.

Table 2: Outcomes by PAC Site
Lower Extremity Joint Replacement Patients
January 2002 to June 2003

First Site of Post-Acute Care	No IRF or SNF Mean	No IRF or SNF Standard Deviation	IRF Mean	IRF Standard Deviation	SNF Mean	SNF Standard Deviation
Functional Status						
Admission/5-Day Barthel Index (0-90)	--	--	45.771	12.660	54.837 **	16.012
Discharge/14-Day Barthel Index (0-90)[1]	--	--	69.496 **	13.741	57.686	18.887
Admission Barthel Index for Those With 14+ Day Stay[1]	--	--	34.562	11.257	47.493 **	15.750
Discharge Barthel Index for Those With 14+ Day Stay[1]	--	--	65.165 **	16.173	57.686	18.887
Observations with 14+ Day Stay	--	--	20,157	13.54%	39,304	30.77%
Walking Score at Admission (0-1)[2]	--	--	0.101	0.302	0.204 **	0.403
Walking Score at Discharge/14 Days (0-1)[2]	--	--	0.850 **	0.357	0.311	0.463
Walking Score at Admission for Those With 14+ Day Stay[1,2]	--	--	0.014	0.117	0.091 **	0.287
Walking Score at Discharge/14 Days for Those With 14+ Day Stay(0-1)[1,2]	--	--	0.760 **	0.427	0.311	0.463
Transfer Score at Admission (0-1)[2]	--	--	0.107	0.310	0.157 **	0.363
Transfer Score at Discharge/14 Days (0-1)[2]	--	--	0.847 **	0.360	0.301	0.458
Transfer Score at Admission for Those With 14+ Day Stay[1,2]	--	--	0.017	0.128	0.075 **	0.264
Transfer Score at Discharge/14 Days for Those With 14+ Day Stay(0-1)[1,2]	--	--	0.792 **	0.406	0.301	0.458
Health Outcomes						
Rehospitalization Within 60 Days	0.070	0.255	0.103 **	0.304	0.075	0.263
Rehospitalization Within 120 Days	0.116	0.320	0.155 **	0.362	0.135	0.342
Custodial Nursing Home At 60 Days	0.000	0.015	0.001	0.039	0.010 **	0.101
Custodial Nursing Home At 120 Days	0.000	0.019	0.003	0.056	0.018 **	0.134
Mortality 30 to 60 Days	0.001	0.029	0.002	0.044	0.004 **	0.066
Mortality Within 120 Days	0.002	0.048	0.005	0.073	0.011 **	0.105
Dead or Custodial Nursing Home at 60 Days	0.001	0.032	0.003	0.059	0.015 **	0.121
Dead or Custodial Nursing Home at 120 Days	0.003	0.051	0.008	0.092	0.029 **	0.169
Independent in Community at 60 Days[3]	0.954	0.210	0.861 **	0.346	0.808	0.394
Independent in Community at 120 Days[3]	0.980	0.139	0.948 **	0.222	0.922	0.268
Independent in Community at 180 Days[3]	0.983	0.128	0.961 **	0.194	0.942	0.234
Length of Stay--60 Day Episodes						
Initial Acute Length of Stay	4.242	2.045	4.067	2.176	4.660 **	2.774
IRF Days	0.019	0.492	9.265 **	4.680	0.145	1.512
SNF Days	0.064	1.221	1.117	5.721	14.937 **	12.537
HHC Days	15.764	16.193	14.857	16.742	15.393 **	15.593
LTCH Days	0.006	0.385	0.049 **	1.137	0.032	0.926
Acute Readmission Days	0.440	2.212	0.825	3.227	0.982 **	3.553
Total Post-Acute Days	**16.294**	**16.522**	**26.113**	**18.888**	**31.489 ****	**18.528**
Total Days in Care	**20.536**	**16.939**	**30.180**	**19.350**	**36.149 ****	**19.265**
Length of Stay--120 Day Episodes						
Initial Acute Length of Stay	4.242	2.045	4.067	2.176	4.660 **	2.774
IRF Days	0.048	0.858	9.467 **	5.104	0.200	1.862
SNF Days	0.154	2.377	1.662	8.717	16.333 **	16.545
HHC Days	16.634	18.194	17.690	21.759	18.999 **	20.845
LTCH Days	0.013	0.643	0.086 **	1.795	0.064	1.568
Acute Readmission Days	0.714	3.056	1.270	4.479	1.527 *	4.953
Total Post-Acute Days	**17.563**	**19.262**	**30.175**	**26.598**	**37.123 ****	**28.085**
Total Days in Care	**21.805**	**19.713**	**34.242**	**27.089**	**41.783 ****	**28.895**
Payments--60 Day Episodes						
Acute Payments	9,508.18	1,940.18	9,753.34 **	2,690.39	9,595.99	2,772.33
IRF Payments-Simulated 100% PPS	20.21	553.15	8,878.63 **	5,840.11	130.75	1,680.36
SNF Payments	19.71	369.76	326.06	1,677.76	4,805.02 **	3,757.91
HHC Payments	1,659.04	1,635.76	1,546.62	1,749.24	1,591.42 **	1,663.22
LTCH Payments	5.01	340.90	32.18 *	861.70	22.63	701.94
Acute Readmission Payments	594.28	3,293.39	916.46	3,998.27	1,054.85 **	4,239.72
Total Post-Acute Payments	**2,298.24**	**3,903.85**	**11,699.95 ****	**8,178.34**	**7,604.66**	**6,339.15**
Total Episode Payments	**11,806.42**	**4,460.53**	**21,453.29 ****	**8,838.08**	**17,200.64**	**7,229.13**
Payments--120 Day Episodes						
Acute Payments	9,508.18	1,940.18	9,753.34 **	2,690.39	9,595.99	2,772.33
IRF Payments-Simulated 100% PPS	51.46	1,288.96	9,078.37 **	6,229.22	181.16	2,061.07
SNF Payments	44.66	666.87	460.50	2,396.60	5,097.26 **	4,516.75
HHC Payments	1,717.32	1,726.80	1,748.20	1,978.20	1,859.30 **	1,900.89
LTCH Payments	9.94	576.28	53.01 *	1,222.12	39.93	1,083.21
Acute Readmission Payments	984.32	4,401.34	1,426.31	5,428.50	1,658.11 **	5,795.85
Total Post-Acute Payments	**2,807.70**	**5,476.10**	**12,766.38 ****	**10,294.68**	**8,835.75**	**8,870.10**
Total Episode Payments	**12,315.88**	**5,924.22**	**22,519.73 ****	**10,871.66**	**18,431.74**	**9,670.16**

Notes: Patients who were in a custodial nursing home before their acute stay, in a custodial nursing home after their acute stay, who used acute rehab (DRG 462), used long term care hospitals, or died in the first 30 days after their acute discharge are excluded from this analysis. This excludes less than 3% of our sample. If payments were 0, we correspondingly set days of care to 0.
A double asterisk (**) indicates a significant t-test for difference between IRF and SNF values at the 0.0001 level.
A single asterisk (*) indicates a significant difference at the 0.05 level. Asterisk is placed next to the higher of the two means.

[1] SNF patients only have a follow-up assessment if they have a 14-Day stay or more.

[2] This dichotomous variable indicates whether the person can walk or transfer on their own (with or without supervision) or not.

[3] Defined as not receiving any acute, PAC, or custodial nursing home care.

Table 3: Regression Output
Lower Extremity Joint Replacement Patients
January 2002 to June 2003

Outcome	Unadjusted Characteristics	Naïve/exogenous Probit			Joint Multinomial Logit Model Probit (for outcomes) or Normal (for payments)		
	Marginal Effect	Marginal Effect	Std. Error	P-value	Marginal Effect	Std. Error	P-value
Dead or institutionalized at post-discharge day 120							
IRF vs. no Medicare-paid institutional care	0.0058	0.0043	0.0004	0.00 **	0.0018	0.0009	0.04 *
SNF vs. no Medicare-paid institutional care	0.0267	0.0120	0.0005	0.00 **	0.0046	0.0008	0.00 **
Dead at post-discharge day 120							
IRF vs. no Medicare-paid institutional care	0.0030	0.0020	0.0003	0.00 **	0.0016	0.0012	0.18
SNF vs. no Medicare-paid institutional care	0.0089	0.0038	0.0003	0.00 **	0.0023	0.0012	0.06
Total PAC payments to post-discharge day 120							
IRF vs. no Medicare-paid institutional care	9,958.68	9,050.13	31.3061	0.00 **	8,297.52	68.0665	0.00 **
SNF vs. no Medicare-paid institutional care	6,028.05	4,684.61	33.0433	0.00 **	3,704.12	60.6226	0.00 **
Total Payments (PAC payments + Acute Stay) to post-discharge day 120							
IRF vs. no Medicare-paid institutional care	10,203.85	8,871.21	32.7081	0.00 **	8,023.00	69.8563	0.00 **
SNF vs. no Medicare-paid institutional care	6,115.86	4,590.17	34.5231	0.00 **	3,577.86	62.9556	0.00 **

Notes: A double asterisk (**) indicates significance at the 0.001 level.
A single asterisk (*) indicates significance at the 0.05 level.

Appendix I

1. Formulation and Estimation of the Joint Model of Site of Care and Outcomes

We begin by presenting a general representation of our model which has two modules, a choice of site of care ("No IRF or SNF", IRF, and SNF) module and a outcome module. The formulation, estimation methods and exposition borrows heavily from Deb and Trivedi (2004). In this model, the choice of site of care and outcome modules are linked because site of care choices are regressors in the outcome module and because there are common unobservable (latent) factors.

Let y_i^* denote the propensity underlying the observed values of outcome, y_i (in the case of payments, $y_i^* = y_i$). Let d_j be a binary variables representing receipt of the j^{th} site of care, with $j = 0, 1, 2$ (corresponding to "No IRF or SNF", IRF, and SNF respectively) and with "No IRF or SNF" as the baseline choice.

The outcome equation for individual i, $i = 1, ..., N$, is formulated as

$$y_i^* = \mathbf{x}_i'\boldsymbol{\beta} + \gamma_1 d_{1i} + \gamma_2 d_{2i} + \sum\nolimits_j \lambda_j l_{ji} + \varepsilon_i \tag{1}$$

where $\mathbf{x}_i$ is a set of exogenous covariates and $\boldsymbol{\beta}$, γ_1, and γ_2 are parameters associated with the exogenous covariates and site of care variables. The error term is partitioned into ε_i, an independently distributed random error, and latent factors l_{ji} which denote unobserved characteristics common to individual i's choice of site of care j and outcome of that individual. The λ_j, factor loadings, are parameters associated with the latent factors.

The transformation from y_i^* given in (1) to the observed random variable y_i is through an appropriate distribution function $\mathbf{f}$ such that

$$\Pr(Y_i = y_i | \mathbf{x}_i, d_{1i,} d_{2i}, l_{ji}) = \mathbf{f}(\mathbf{x}_i'\boldsymbol{\beta} + \gamma_1 d_{1i} + \gamma_2 d_{2i} + \sum\nolimits_j \lambda_j l_{ji}). \tag{2}$$

In the case of the binary outcome, $\mathbf{f}$ is assumed to be the normal distribution function, i.e, the outcome equation is a probit model. In the linear case $\mathbf{f}$ is the identity link.

Following the random utility framework (McFadden, 1980, p. S15), the propensity to select site of care j, $j = 0, 1, 2$, is formulated as

$$U^*_{ji} = \mathbf{z}_i'\boldsymbol{\alpha}_j + \delta_j l_{ji} + \eta_{ji}. \tag{3}$$

where $\mathbf{z}_i$ denotes exogenous covariates, α_j the associated parameters and η_{ji} are random error terms assumed to be independent of ε_i. Once again, l_{ji} are latent factors and δ_j are associated factor loadings. The transformation from the latent variable formulation to the observed multinomial choices is via a distribution function $\mathbf{g}$ such that

$$\Pr(d_{ji} = 1|\mathbf{z}_i, l_{ji}) = \mathbf{g}(\mathbf{z}_i'\boldsymbol{\alpha}_j + \delta_j l_{ji}), \quad j = 0, 1, 2. \tag{4}$$

We denote covariates in this site-choice module by $\mathbf{z}$ and covariates in the outcome module by $\mathbf{x}$ to highlight the fact that they contain different variables in the empirical analysis. In this study, we use the extreme value distribution for $\mathbf{g}$ so that the model for site of care is a multinomial logit.

Because the latent factors l_{ji} enter both choice of site of care (4) and outcome (2) equations, they capture the individual-specific factors that induce self-selection into site of care through unobservables on outcomes.

Under these assumptions, the joint distribution of selection and outcome variables, conditional on the common latent factors, can be written as

$$\begin{aligned}\Pr(Y_i = y_i, d_{ji} = 1|\mathbf{x}_i, \mathbf{z}_i, l_{ji}) \;&=\; \mathbf{f}(\mathbf{x}_i'\boldsymbol{\beta} + \gamma_1 d_{1i} + \gamma_2 d_{2i} + \textstyle\sum_j \lambda_j l_{ji}) \\ &\quad\times \mathbf{g}(\mathbf{z}_i'\boldsymbol{\alpha}_j + \delta_j l_{ji})\end{aligned}\;. \tag{5}$$

The problem in estimation arises because the l_{ji} are unknown. We assume that the distribution of l_{ji}, $\mathbf{h}_j$, is known (normally distributed) and can therefore be integrated out of the joint density, i.e.,

$$\begin{aligned}\Pr(Y_i = y_i, d_{ji} = 1|\mathbf{x}_i, \mathbf{z}_i) \;&=\; \int \Big[\mathbf{f}(\mathbf{x}_i'\boldsymbol{\beta} + \gamma_1 d_{1i} + \gamma_2 d_{2i} + \textstyle\sum_j \lambda_j l_{ji}) \\ &\quad\times \mathbf{g}(\mathbf{z}_i'\boldsymbol{\alpha}_j + \delta_j l_{ji})\Big]\, \mathbf{h}_j(l_{ji}) dl_{ji}\end{aligned}\;. \tag{6}$$

Cast in this form, the unknown parameters of the model may be estimated by maximum likelihood.

The main computational problem, given suitable specifications for $\mathbf{f}$, $\mathbf{g}$ and $\mathbf{h}_j$, is that the integral (6)does not have, in general, a closed form solution. But this difficulty can be addressed using simulation-based estimation (Gourieroux and Monfort, 1996) by noting that

$$\begin{aligned}\Pr(Y_i = y_i, d_{ji} = 1|\mathbf{x}_i, \mathbf{z}_i) &= \mathrm{E}\Big[\mathbf{f}(x_i'\boldsymbol{\beta} + \gamma_1 d_{1i} + \gamma_2 d_{2i} + \textstyle\sum_j \lambda_j l_{ji}) \\ &\quad \times \mathbf{g}(z_i'\boldsymbol{\alpha}_j + \delta_j l_{ji})] \\ &\approx \frac{1}{S}\sum_{s=1}^{S}\Big[\mathbf{f}(\mathbf{x}_i'\boldsymbol{\beta} + \gamma_1 d_{1i} + \gamma_2 d_{2i} + \textstyle\sum_j \lambda_j \widetilde{l}_{jis}) \\ &\quad \times \mathbf{g}(z_i'\boldsymbol{\alpha}_j + \delta_j \widetilde{l}_{jis})\Big]\end{aligned} \quad , \qquad (7)$$

where $\widetilde{l}_{jis}$ is the s^{th} draw (from a total of S draws) of a pseudo-random number from the density $\mathbf{h}_j$ and $\widetilde{\Pr}$ denotes the simulated probability. A simulated likelihood function for the data can then be defined. The MSL estimator maximizes the average simulated log likelihood. Because of the complexity of our model, standard simulation methods are quite slow. Therefore, we adapt an acceleration technique that uses quasi-random draws based on Halton sequences (Bhat, 2001; Train, 2002).We maximize the simulated likelihood using a quasi-Newton algorithm.

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Appendix II: Regression Results for Outcomes and Payments (Probit Models)
Lower Extremity Joint Replacement Patients
January 2002 to June 2003
Outcomes Measured at 120 Days

Dependent Variable	Dead or Institutionalized			Dead			Post-Acute Payments			Total Payments		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable							($thousands)			($thousands)		
IRF Effect	0.002	0.001	2.01	0.002	0.001	1.36	8.298	0.068	121.90	8.023	0.070	114.85
SNF Effect	0.005	0.001	6.11	0.002	0.001	1.88	3.704	0.061	61.10	3.578	0.063	56.83
Age	-0.023	0.042	-0.55	-0.011	0.038	-0.29	-97.437	6.062	-16.07	-92.560	6.326	-14.63
Age Squared	0.050	0.027	1.84	0.029	0.025	1.17	74.140	3.952	18.76	71.799	4.128	17.39
Female	0.003	0.063	0.05	0.001	0.095	0.01	-8.323	2.790	-2.98	-6.333	2.909	-2.18
Female*Age	-0.011	0.050	-0.21	0.000	0.047	-0.01	22.699	7.295	3.11	17.472	7.611	2.30
Female*Age Squared	0.007	0.031	0.22	-0.003	0.029	-0.12	-14.414	4.747	-3.04	-11.038	4.957	-2.23
Black	-0.001	0.000	-2.13	0.001	0.000	1.52	1.045	0.046	22.49	1.237	0.048	25.74
Hispanic	-0.003	0.000	-7.79	-0.001	0.001	-1.20	0.174	0.106	1.64	0.669	0.110	6.06
Other Race	-0.002	0.000	-6.53	-0.001	0.000	-2.81	-0.323	0.081	-3.99	-0.269	0.084	-3.20
Beneficiary is covered by Medicaid	0.014	0.001	17.96	0.001	0.000	3.19	2.202	0.035	62.96	2.484	0.036	68.05
Lives in an MSA	0.000	0.000	0.35	0.000	0.000	1.34	0.081	0.036	2.26	-0.084	0.038	-2.24
Lives adjacent to an MSA	0.000	0.000	-0.52	0.000	0.000	0.31	0.167	0.040	4.17	0.012	0.042	0.30
Post-operative pulmonary compromise	0.006	0.001	3.88	0.003	0.001	2.34	2.139	0.095	22.54	4.173	0.084	49.61
Post-operative GI hemorrhage or ulceration	0.003	0.002	1.76	0.001	0.001	0.80	2.283	0.154	14.78	3.540	0.134	26.49
Cellulitis or decubitus ulcer	0.018	0.002	7.75	0.009	0.002	4.84	4.168	0.096	43.21	4.616	0.097	47.67
Septicemia	0.003	0.005	0.69	-0.001	0.004	-0.16	4.588	0.271	16.93	5.915	0.280	21.10
Mechanical complications due to device or implant	0.005	0.001	5.73	0.002	0.001	3.13	2.537	0.068	37.35	3.037	0.068	44.68
Miscellaneous complications	0.000	0.001	0.16	-0.001	0.000	-1.27	-0.120	0.083	-1.44	-0.041	0.084	-0.49
Shock or cardiorespiratory arrest	0.005	0.002	1.90	0.001	0.002	0.45	3.649	0.174	20.98	5.860	0.161	36.38
Post-op heart attack (AMI)	0.005	0.001	3.50	0.004	0.001	3.04	5.962	0.085	69.83	6.771	0.086	79.08
Post-op cardiac abnormalities other than AMI	-0.002	0.002	-1.34	0.000	0.003	0.07	0.892	0.290	3.08	2.326	0.254	9.17
Procedure-related laceration or perforation	0.001	0.002	0.45	0.002	0.003	0.89	0.705	0.266	2.65	1.916	0.239	8.02
Venous thrombosis or pulmonary embolism	0.002	0.001	1.94	0.002	0.001	1.41	1.155	0.114	10.14	1.733	0.109	15.93
Iatrogenic complications	0.001	0.000	2.05	0.001	0.000	1.43	0.475	0.048	9.89	0.734	0.048	15.22
Sentinel Events	0.006	0.004	1.70	0.005	0.004	1.31	2.528	0.210	12.04	4.416	0.191	23.11
Acute renal failure	0.005	0.001	3.83	0.004	0.001	3.27	3.373	0.086	39.23	4.294	0.082	52.42
Delirium	0.004	0.001	4.29	0.002	0.001	2.35	1.507	0.072	20.81	1.616	0.076	21.20
Cancer with a Poor Prognosis	0.011	0.003	4.46	0.012	0.003	4.29	1.149	0.149	7.73	1.209	0.156	7.74
Metastatic Cancer	0.065	0.011	5.74	0.074	0.013	5.77	1.632	0.255	6.40	1.906	0.263	7.25
Chronic Pulmonary Disease	0.002	0.000	7.49	0.002	0.000	6.51	0.710	0.032	22.52	0.767	0.033	23.31
Coronary Artery Disease	0.000	0.000	2.07	0.000	0.000	2.02	0.562	0.027	20.89	0.593	0.028	21.01
Congestive Heart Failure	0.005	0.000	11.47	0.004	0.001	8.16	1.853	0.036	51.32	2.046	0.037	55.01
Peripheral Vascular Disease	0.002	0.001	2.53	0.001	0.001	1.84	0.831	0.064	12.98	0.786	0.067	11.66
Severe Chronic Liver Disease	0.016	0.004	4.01	0.020	0.005	3.98	3.040	0.196	15.55	3.503	0.187	18.74
Diabetes with End Organ Damage	0.007	0.001	4.93	0.004	0.001	3.38	2.651	0.083	31.95	2.478	0.088	28.11
Chronic Renal Failure	0.022	0.004	5.00	0.024	0.005	4.83	3.925	0.151	25.93	4.062	0.153	26.62
Nutritional Deficiencies	0.012	0.003	4.71	0.007	0.002	3.10	2.733	0.144	18.92	4.594	0.125	36.79
Dementia	0.037	0.002	15.67	0.007	0.001	6.26	2.862	0.075	38.01	2.895	0.080	36.36
Functional Impairment	0.010	0.001	6.75	0.003	0.001	2.96	3.000	0.081	36.90	2.984	0.087	34.47
Diabetes without End Organ Damage	0.002	0.000	6.97	0.001	0.000	4.09	0.899	0.029	31.18	0.930	0.030	30.72
Pneumonia	0.007	0.001	5.85	0.004	0.001	3.86	2.169	0.080	27.20	3.005	0.076	39.47
Stroke	0.030	0.006	4.95	0.009	0.004	2.42	9.458	0.138	68.55	10.532	0.142	74.21

Appendix II: Regression Results for Outcomes and Payments (Probit Models)
Lower Extremity Joint Replacement Patients
January 2002 to June 2003
Outcomes Measured at 120 Days

Dependent Variable	Dead or Institutionalized			Dead			Post-Acute Payments			Total Payments		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable							($thousands)			($thousands)		
Hip Replacement	0.008	0.005	1.61	0.003	0.004	0.61	2.686	0.370	7.25	3.955	0.328	12.05
Total Hip Replacement	-0.003	0.002	-1.85	-0.002	0.002	-0.98	-1.520	0.297	-5.12	-1.213	0.258	-4.69
Partial Hip Replacement	0.012	0.007	1.75	0.007	0.007	0.90	1.943	0.303	6.41	2.731	0.266	10.26
Hip Revision	0.003	0.003	0.97	0.001	0.003	0.22	0.714	0.296	2.41	1.426	0.258	5.53
Knee Replacement	0.004	0.003	1.35	0.000	0.006	0.08	2.369	0.389	6.09	4.329	0.390	11.11
Total Knee Replacement	-0.003	0.004	-0.92	-0.002	0.006	-0.27	-1.983	0.322	-6.15	-2.403	0.338	-7.10
Knee Revision	0.000	0.004	0.13	0.001	0.008	0.07	-0.682	0.320	-2.13	-0.857	0.336	-2.55
Bilateral Procedure	0.000	0.001	0.61	0.000	0.000	-0.96	0.841	0.058	14.50	6.500	0.058	112.21
Non-Profit Hospital	0.000	0.000	0.26	0.000	0.000	-1.71	-0.948	0.032	-29.38	-1.193	0.033	-35.97
Government Hospital	0.000	0.000	0.01	0.000	0.000	-0.80	-0.727	0.045	-16.00	-0.812	0.047	-17.18
Average Daily Census of Hospital	0.000	0.000	-0.66	0.000	0.000	-0.30	0.186	0.008	24.64	0.258	0.008	33.09
Resident to ADC ratio of Hospital	0.001	0.000	2.05	0.000	0.000	-0.08	0.925	0.052	17.68	4.079	0.054	75.86
Percentage of Low Income Patients	0.002	0.001	1.68	0.003	0.001	2.54	1.522	0.137	11.13	7.365	0.142	51.94
% Medicare days	0.001	0.001	1.57	0.000	0.001	-0.02	2.252	0.116	19.48	1.839	0.120	15.30
Case Mix Index of Hospital	-0.002	0.000	-4.72	-0.001	0.000	-1.91	-1.042	0.057	-18.18	-1.147	0.060	-19.21
HMO Penetration Rate	0.000	0.000	-1.87	0.000	0.000	-0.53	0.011	0.001	10.63	0.012	0.001	10.86

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit)

Lower Extremity Joint Replacement Patients

January 2002 to June 2003

Total Payments -- 120 Day Episodes

Dependent Variable	No IRF or SNF			IRF Care			SNF Care		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable									
Age	0.067	0.501	0.134	3.094	0.508	6.091	-3.161	0.485	-6.513
Age Squared	-1.339	0.340	-3.935	-1.635	0.318	-5.141	2.973	0.316	9.408
Female	0.523	0.119	4.402	0.131	0.171	0.770	-0.654	0.161	-4.077
Female*Age	-2.359	0.644	-3.663	0.178	0.609	0.293	2.181	0.566	3.851
Female*Age Squared	1.626	0.418	3.893	-0.174	0.404	-0.432	-1.451	0.391	-3.712
Black	-0.078	0.003	-22.538	0.104	0.004	27.208	-0.026	0.004	-7.389
Hispanic	-0.019	0.009	-2.181	0.078	0.009	8.733	-0.059	0.007	-8.131
Other Race	-0.009	0.006	-1.638	0.034	0.006	5.934	-0.025	0.005	-4.549
Beneficiary is covered by Medicaid	-0.100	0.003	-35.224	0.027	0.003	8.439	0.073	0.003	23.978
Lives in an MSA	-0.157	0.004	-39.413	0.079	0.004	21.435	0.078	0.004	22.292
Lives adjacent to an MSA	-0.088	0.003	-29.760	0.032	0.004	9.011	0.056	0.003	16.380
Post-operative pulmonary compromise	-0.074	0.011	-6.734	0.000	0.011	0.019	0.074	0.011	6.806
Post-operative GI hemorrhage or ulceration	-0.031	0.017	-1.789	-0.032	0.016	-1.961	0.062	0.016	3.821
Cellulitis or decubitus ulcer	-0.072	0.011	-6.708	-0.046	0.010	-4.425	0.117	0.011	10.555
Septicemia	-0.159	0.031	-5.124	-0.073	0.036	-2.036	0.232	0.039	5.911
Mechanical complications due to device or implant	-0.061	0.007	-8.357	-0.006	0.007	-0.813	0.067	0.007	9.043
Miscellaneous complications	-0.005	0.007	-0.777	-0.039	0.007	-5.502	0.045	0.007	6.235
Shock or cardiorespiratory arrest	-0.066	0.024	-2.700	-0.018	0.023	-0.782	0.084	0.023	3.606
Post-op heart attack (AMI)	-0.020	0.014	-1.487	-0.002	0.012	-0.170	0.022	0.012	1.886
Post-op cardiac abnormalities other than AMI	0.035	0.036	0.961	-0.032	0.032	-1.024	-0.002	0.030	-0.081
Procedure-related laceration or perforation	0.033	0.025	1.315	-0.023	0.023	-1.003	-0.010	0.022	-0.438
Venous thrombosis or pulmonary embolism	-0.025	0.010	-2.483	0.031	0.010	3.148	-0.005	0.010	-0.517
Iatrogenic complications	-0.036	0.004	-9.148	0.007	0.004	1.710	0.029	0.004	7.109
Sentinel Events	-0.025	0.023	-1.065	-0.014	0.024	-0.593	0.039	0.023	1.672
Acute renal failure	-0.116	0.010	-11.946	0.039	0.010	3.843	0.078	0.010	7.670
Delirium	-0.127	0.006	-21.125	0.028	0.007	4.073	0.100	0.007	14.597
Cancer with a Poor Prognosis	-0.008	0.014	-0.608	0.007	0.013	0.550	0.001	0.013	0.066
Metastatic Cancer	-0.023	0.026	-0.899	-0.026	0.025	-1.024	0.049	0.026	1.869
Chronic Pulmonary Disease	-0.051	0.002	-20.698	0.020	0.003	7.786	0.031	0.003	12.499
Coronary Artery Disease	-0.037	0.002	-18.196	0.030	0.002	14.155	0.007	0.002	3.459
Congestive Heart Failure	-0.081	0.004	-22.902	0.024	0.004	6.469	0.057	0.004	15.937
Peripheral Vascular Disease	-0.043	0.006	-7.663	0.018	0.006	3.040	0.025	0.006	4.538
Severe Chronic Liver Disease	-0.084	0.018	-4.721	0.024	0.019	1.253	0.060	0.020	2.941

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit) Lower Extremity Joint Replacement Patients January 2002 to June 2003 Total Payments -- 120 Day Episodes									
Dependent Variable	**No IRF or SNF**			**IRF Care**			**SNF Care**		
	Marginal Effect	**Standard Error**	**T-Statistic**	**Marginal Effect**	**Standard Error**	**T-Statistic**	**Marginal Effect**	**Standard Error**	**T-Statistic**
Independent Variable									
Diabetes with End Organ Damage	-0.137	0.007	-20.513	0.053	0.008	6.280	0.084	0.009	9.747
Chronic Renal Failure	-0.039	0.019	-2.032	-0.027	0.017	-1.519	0.066	0.019	3.414
Nutritional Deficiencies	-0.130	0.015	-8.507	-0.008	0.016	-0.491	0.138	0.017	8.249
Dementia	-0.125	0.007	-18.096	-0.071	0.007	-10.581	0.196	0.008	24.733
Functional Impairment	-0.145	0.007	-21.069	0.091	0.008	10.713	0.054	0.008	6.720
Diabetes without End Organ Damage	-0.077	0.002	-36.529	0.031	0.002	13.324	0.046	0.002	20.487
Pneumonia	-0.058	0.009	-6.654	-0.021	0.009	-2.383	0.078	0.009	8.887
Stroke	-0.197	0.017	-11.952	0.111	0.022	5.094	0.086	0.021	4.213
Hip Replacement	-0.513	0.025	-20.923	0.388	0.038	10.302	0.125	0.034	3.628
Total Hip Replacement	0.278	0.037	7.475	-0.179	0.029	-6.073	-0.099	0.026	-3.848
Partial Hip Replacement	0.198	0.038	5.163	-0.185	0.024	-7.819	-0.013	0.031	-0.413
Hip Revision	0.331	0.036	9.100	-0.219	0.022	-9.922	-0.111	0.025	-4.535
Knee Replacement	-0.286	0.041	-6.920	0.194	0.033	5.819	0.092	0.035	2.623
Total Knee Replacement	-0.017	0.035	-0.474	0.040	0.027	1.463	-0.023	0.029	-0.800
Knee Revision	0.067	0.038	1.762	-0.027	0.028	-0.958	-0.040	0.027	-1.494
Bilateral Procedure	-0.248	0.002	-101.486	0.215	0.004	49.102	0.033	0.004	7.842
Non-Profit Hospital	0.055	0.002	24.913	-0.110	0.002	-45.035	0.055	0.002	25.148
Government Hospital	0.057	0.004	14.996	-0.089	0.003	-28.460	0.032	0.004	8.411
Average Daily Census of Hospital	-0.014	0.001	-25.084	0.015	0.001	27.895	0.000	0.001	-0.721
Resident to ADC ratio of Hospital	-0.045	0.004	-10.472	-0.001	0.004	-0.248	0.046	0.004	11.485
Percentage of Low Income Patients	-0.080	0.010	-7.645	0.159	0.010	16.253	-0.079	0.010	-7.560
% Medicare days	-0.263	0.008	-31.659	0.106	0.008	13.016	0.156	0.008	19.818
Case Mix Index of Hospital	0.136	0.004	31.996	0.109	0.004	26.213	-0.245	0.004	-60.533
HMO Penetration Rate	-0.001	0.000	-17.121	-0.002	0.000	-22.277	0.003	0.000	41.290
IRFs within travel radius (00)	-0.214	0.012	-17.300	0.917	0.013	73.337	-0.703	0.011	-61.517
SNFs within travel radius (00)	-0.038	0.003	-11.214	-0.182	0.004	-51.303	0.220	0.003	68.280
Distance to nearest SNF (00 miles)	0.242	0.022	10.990	0.279	0.022	12.896	-0.522	0.021	-25.374
Distance to nearest IRF (00 miles)	0.050	0.007	6.945	-0.619	0.007	-82.606	0.570	0.007	78.966
No IRFs within travel radius (00)	0.069	0.006	11.045	-0.026	0.006	-4.065	-0.043	0.005	-8.773
No SNFs within travel radius (00)	0.010	0.026	0.404	0.048	0.027	1.795	-0.059	0.024	-2.491
Distance to nearest SNF squared (00 miles)	-0.766	0.039	-19.777	0.351	0.033	10.648	0.415	0.034	12.069
Distance to nearest IRF squared (00 miles)	0.034	0.002	19.521	0.147	0.001	99.889	-0.181	0.002	-103.656

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit)
Lower Extremity Joint Replacement Patients
January 2002 to June 2003
Total PAC Payments -- 120 Day Episodes

Dependent Variable	No IRF or SNF			IRF Care			SNF Care		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable									
Age	0.068	0.501	0.135	3.094	0.508	6.092	-3.162	0.485	-6.513
Age Squared	-1.339	0.340	-3.937	-1.635	0.318	-5.143	2.974	0.316	9.407
Female	0.523	0.119	4.402	0.132	0.171	0.771	-0.654	0.161	-4.077
Female*Age	-2.359	0.644	-3.664	0.178	0.609	0.292	2.182	0.566	3.851
Female*Age Squared	1.626	0.418	3.893	-0.174	0.404	-0.431	-1.452	0.391	-3.712
Black	-0.078	0.003	-22.530	0.104	0.004	27.201	-0.026	0.004	-7.385
Hispanic	-0.019	0.009	-2.178	0.078	0.009	8.733	-0.059	0.007	-8.131
Other Race	-0.009	0.006	-1.637	0.034	0.006	5.933	-0.025	0.005	-4.548
Beneficiary is covered by Medicaid	-0.100	0.003	-35.232	0.027	0.003	8.426	0.073	0.003	23.985
Lives in an MSA	-0.157	0.004	-39.410	0.079	0.004	21.433	0.078	0.004	22.287
Lives adjacent to an MSA	-0.088	0.003	-29.765	0.032	0.004	9.001	0.056	0.003	16.389
Post-operative pulmonary compromise	-0.074	0.011	-6.774	0.000	0.011	0.018	0.074	0.011	6.833
Post-operative GI hemorrhage or ulceration	-0.031	0.017	-1.789	-0.032	0.016	-1.961	0.062	0.016	3.828
Cellulitis or decubitus ulcer	-0.072	0.011	-6.707	-0.046	0.010	-4.433	0.117	0.011	10.567
Septicemia	-0.159	0.031	-5.134	-0.073	0.036	-2.038	0.232	0.039	5.914
Mechanical complications due to device or implant	-0.061	0.007	-8.367	-0.006	0.007	-0.815	0.067	0.007	9.052
Miscellaneous complications	-0.005	0.007	-0.779	-0.039	0.007	-5.503	0.045	0.007	6.235
Shock or cardiorespiratory arrest	-0.066	0.024	-2.723	-0.018	0.023	-0.786	0.084	0.023	3.628
Post-op heart attack (AMI)	-0.020	0.014	-1.491	-0.002	0.012	-0.171	0.022	0.012	1.893
Post-op cardiac abnormalities other than AMI	0.035	0.036	0.964	-0.032	0.032	-1.017	-0.002	0.030	-0.082
Procedure-related laceration or perforation	0.033	0.025	1.316	-0.023	0.023	-1.006	-0.010	0.022	-0.440
Venous thrombosis or pulmonary embolism	-0.025	0.010	-2.484	0.031	0.010	3.150	-0.005	0.010	-0.518
Iatrogenic complications	-0.036	0.004	-9.155	0.007	0.004	1.710	0.029	0.004	7.110
Sentinel Events	-0.025	0.023	-1.067	-0.014	0.024	-0.593	0.039	0.023	1.670
Acute renal failure	-0.116	0.010	-11.990	0.039	0.010	3.845	0.078	0.010	7.686
Delirium	-0.127	0.006	-21.143	0.028	0.007	4.072	0.100	0.007	14.601
Cancer with a Poor Prognosis	-0.008	0.014	-0.608	0.007	0.013	0.550	0.001	0.013	0.066
Metastatic Cancer	-0.023	0.026	-0.898	-0.026	0.025	-1.024	0.049	0.026	1.871
Chronic Pulmonary Disease	-0.051	0.002	-20.707	0.019	0.003	7.776	0.031	0.003	12.510
Coronary Artery Disease	-0.037	0.002	-18.206	0.030	0.002	14.161	0.007	0.002	3.461
Congestive Heart Failure	-0.081	0.004	-22.915	0.024	0.004	6.463	0.057	0.004	15.944
Peripheral Vascular Disease	-0.043	0.006	-7.662	0.018	0.006	3.037	0.025	0.006	4.540
Severe Chronic Liver Disease	-0.084	0.018	-4.719	0.024	0.019	1.250	0.060	0.020	2.940

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit)

Lower Extremity Joint Replacement Patients

January 2002 to June 2003

Total PAC Payments -- 120 Day Episodes

Dependent Variable	No IRF or SNF			IRF Care			SNF Care		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable									
Diabetes with End Organ Damage	-0.137	0.007	-20.525	0.053	0.008	6.277	0.084	0.009	9.749
Chronic Renal Failure	-0.039	0.019	-2.044	-0.027	0.017	-1.524	0.066	0.019	3.422
Nutritional Deficiencies	-0.130	0.015	-8.515	-0.008	0.016	-0.494	0.138	0.017	8.268
Dementia	-0.125	0.007	-18.108	-0.071	0.007	-10.590	0.196	0.008	24.742
Functional Impairment	-0.145	0.007	-21.072	0.091	0.008	10.711	0.054	0.008	6.720
Diabetes without End Organ Damage	-0.077	0.002	-36.540	0.031	0.002	13.323	0.046	0.002	20.488
Pneumonia	-0.058	0.009	-6.661	-0.021	0.009	-2.385	0.078	0.009	8.893
Stroke	-0.197	0.016	-12.064	0.111	0.022	5.103	0.087	0.021	4.218
Hip Replacement	-0.513	0.024	-20.948	0.388	0.038	10.293	0.125	0.034	3.639
Total Hip Replacement	0.278	0.037	7.502	-0.179	0.029	-6.068	-0.099	0.026	-3.860
Partial Hip Replacement	0.198	0.038	5.182	-0.185	0.024	-7.815	-0.013	0.031	-0.415
Hip Revision	0.331	0.036	9.134	-0.219	0.022	-9.919	-0.111	0.024	-4.553
Knee Replacement	-0.286	0.041	-6.916	0.194	0.033	5.819	0.092	0.035	2.625
Total Knee Replacement	-0.017	0.035	-0.473	0.040	0.027	1.462	-0.023	0.029	-0.799
Knee Revision	0.067	0.038	1.762	-0.027	0.028	-0.958	-0.040	0.027	-1.494
Bilateral Procedure	-0.248	0.002	-101.494	0.214	0.004	49.075	0.033	0.004	7.835
Non-Profit Hospital	0.055	0.002	24.900	-0.110	0.002	-45.042	0.055	0.002	25.164
Government Hospital	0.057	0.004	14.993	-0.089	0.003	-28.463	0.032	0.004	8.414
Average Daily Census of Hospital	-0.015	0.001	-25.139	0.015	0.001	27.908	0.000	0.001	-0.675
Resident to ADC ratio of Hospital	-0.045	0.004	-10.472	-0.001	0.004	-0.248	0.046	0.004	11.482
Percentage of Low Income Patients	-0.080	0.010	-7.643	0.159	0.010	16.258	-0.079	0.010	-7.563
% Medicare days	-0.263	0.008	-31.663	0.106	0.008	13.011	0.156	0.008	19.821
Case Mix Index of Hospital	0.136	0.004	31.992	0.109	0.004	26.212	-0.245	0.004	-60.512
HMO Penetration Rate	-0.001	0.000	-16.931	-0.002	0.000	-22.139	0.003	0.000	40.927
IRFs within travel radius (00)	-0.213	0.012	-17.288	0.917	0.013	73.333	-0.704	0.011	-61.536
SNFs within travel radius (00)	-0.038	0.003	-11.215	-0.182	0.004	-51.304	0.220	0.003	68.276
Distance to nearest SNF (00 miles)	0.243	0.022	10.993	0.279	0.022	12.900	-0.522	0.021	-25.375
Distance to nearest IRF (00 miles)	0.050	0.007	6.923	-0.620	0.007	-82.617	0.570	0.007	79.001
No IRFs within travel radius (00)	0.069	0.006	11.049	-0.026	0.006	-4.064	-0.043	0.005	-8.771
No SNFs within travel radius (00)	0.010	0.026	0.404	0.048	0.027	1.795	-0.059	0.024	-2.494
Distance to nearest SNF squared (00 miles)	-0.766	0.039	-19.763	0.351	0.033	10.640	0.415	0.034	12.059
Distance to nearest IRF squared (00 miles)	0.034	0.002	19.526	0.147	0.001	99.779	-0.181	0.002	-103.632

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit)
Lower Extremity Joint Replacement Patients
January 2002 to June 2003
Dead or Institutionalized at 120 Days

Dependent Variable	No IRF or SNF			IRF Care			SNF Care		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable									
Age	0.065	0.517	0.126	3.093	0.498	6.217	-3.158	0.504	-6.264
Age Squared	-1.338	0.328	-4.080	-1.633	0.328	-4.971	2.971	0.315	9.432
Female	0.523	0.130	4.033	0.131	0.175	0.748	-0.654	0.162	-4.027
Female*Age	-2.360	0.617	-3.826	0.180	0.597	0.302	2.180	0.564	3.865
Female*Age Squared	1.626	0.414	3.927	-0.176	0.396	-0.443	-1.450	0.367	-3.952
Black	-0.078	0.003	-22.546	0.104	0.004	27.487	-0.026	0.004	-7.218
Hispanic	-0.019	0.009	-2.195	0.078	0.009	8.717	-0.059	0.008	-7.647
Other Race	-0.009	0.006	-1.698	0.034	0.006	6.037	-0.025	0.005	-4.597
Beneficiary is covered by Medicaid	-0.100	0.003	-36.185	0.027	0.003	8.701	0.073	0.003	24.328
Lives in an MSA	-0.157	0.004	-40.283	0.079	0.004	20.586	0.078	0.004	22.204
Lives adjacent to an MSA	-0.088	0.003	-29.586	0.032	0.004	8.783	0.056	0.003	16.518
Post-operative pulmonary compromise	-0.074	0.011	-6.813	0.000	0.011	0.026	0.074	0.011	6.703
Post-operative GI hemorrhage or ulceration	-0.031	0.017	-1.779	-0.032	0.016	-2.009	0.062	0.016	3.905
Cellulitis or decubitus ulcer	-0.072	0.011	-6.745	-0.046	0.010	-4.352	0.117	0.011	10.709
Septicemia	-0.159	0.030	-5.282	-0.073	0.035	-2.089	0.232	0.038	6.054
Mechanical complications due to device or implant	-0.061	0.007	-8.447	-0.006	0.007	-0.815	0.067	0.007	8.946
Miscellaneous complications	-0.005	0.007	-0.746	-0.039	0.007	-5.445	0.044	0.007	6.354
Shock or cardiorespiratory arrest	-0.066	0.024	-2.774	-0.018	0.023	-0.805	0.084	0.023	3.673
Post-op heart attack (AMI)	-0.020	0.013	-1.594	-0.002	0.012	-0.169	0.022	0.012	1.940
Post-op cardiac abnormalities other than AMI	0.035	0.035	1.004	-0.032	0.031	-1.053	-0.002	0.030	-0.082
Procedure-related laceration or perforation	0.033	0.023	1.417	-0.023	0.022	-1.065	-0.010	0.021	-0.458
Venous thrombosis or pulmonary embolism	-0.025	0.010	-2.574	0.031	0.010	3.082	-0.005	0.010	-0.528
Iatrogenic complications	-0.036	0.004	-8.746	0.007	0.004	1.705	0.029	0.004	6.952
Sentinel Events	-0.025	0.024	-1.034	-0.014	0.024	-0.579	0.039	0.023	1.685
Acute renal failure	-0.116	0.009	-12.796	0.039	0.010	3.856	0.078	0.010	7.835
Delirium	-0.128	0.006	-20.463	0.028	0.007	4.051	0.100	0.007	15.067
Cancer with a Poor Prognosis	-0.008	0.014	-0.586	0.007	0.014	0.536	0.001	0.013	0.068
Metastatic Cancer	-0.023	0.026	-0.917	-0.026	0.026	-1.003	0.049	0.025	1.950
Chronic Pulmonary Disease	-0.051	0.002	-20.907	0.020	0.003	7.620	0.031	0.002	12.913
Coronary Artery Disease	-0.037	0.002	-17.285	0.030	0.002	13.816	0.007	0.002	3.592
Congestive Heart Failure	-0.081	0.003	-23.434	0.024	0.004	6.766	0.057	0.004	15.850
Peripheral Vascular Disease	-0.043	0.006	-7.665	0.018	0.006	3.086	0.025	0.005	4.639
Severe Chronic Liver Disease	-0.084	0.017	-4.993	0.024	0.018	1.308	0.060	0.020	3.052

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit)
Lower Extremity Joint Replacement Patients
January 2002 to June 2003
Dead or Institutionalized at 120 Days

Dependent Variable	No IRF or SNF			IRF Care			SNF Care		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable									
Diabetes with End Organ Damage	-0.138	0.007	-20.193	0.053	0.008	6.374	0.084	0.008	10.415
Chronic Renal Failure	-0.039	0.019	-2.061	-0.027	0.018	-1.487	0.066	0.019	3.467
Nutritional Deficiencies	-0.130	0.016	-8.277	-0.008	0.017	-0.457	0.138	0.017	8.157
Dementia	-0.125	0.007	-17.339	-0.071	0.007	-10.804	0.196	0.008	25.030
Functional Impairment	-0.145	0.007	-20.688	0.091	0.009	10.563	0.054	0.009	6.354
Diabetes without End Organ Damage	-0.077	0.002	-37.972	0.031	0.002	13.605	0.046	0.002	20.355
Pneumonia	-0.058	0.009	-6.396	-0.021	0.009	-2.350	0.078	0.009	8.891
Stroke	-0.198	0.016	-12.188	0.111	0.021	5.332	0.087	0.021	4.198
Hip Replacement	-0.513	0.025	-20.419	0.389	0.038	10.288	0.125	0.034	3.707
Total Hip Replacement	0.278	0.038	7.320	-0.179	0.030	-5.955	-0.099	0.027	-3.637
Partial Hip Replacement	0.198	0.039	5.022	-0.185	0.024	-7.616	-0.013	0.031	-0.407
Hip Revision	0.331	0.035	9.410	-0.219	0.023	-9.623	-0.111	0.024	-4.653
Knee Replacement	-0.286	0.040	-7.075	0.194	0.033	5.870	0.092	0.032	2.858
Total Knee Replacement	-0.017	0.035	-0.482	0.040	0.028	1.412	-0.023	0.029	-0.796
Knee Revision	0.067	0.038	1.776	-0.027	0.028	-0.954	-0.040	0.028	-1.428
Bilateral Procedure	-0.248	0.002	-105.010	0.215	0.004	51.344	0.033	0.004	8.216
Non-Profit Hospital	0.055	0.002	24.000	-0.110	0.003	-44.002	0.055	0.002	23.279
Government Hospital	0.057	0.004	15.536	-0.089	0.003	-27.517	0.032	0.004	8.966
Average Daily Census of Hospital	-0.014	0.001	-24.505	0.015	0.001	27.807	0.000	0.001	-0.820
Resident to ADC ratio of Hospital	-0.045	0.004	-10.369	-0.001	0.004	-0.226	0.046	0.004	10.763
Percentage of Low Income Patients	-0.080	0.011	-7.355	0.159	0.010	16.041	-0.079	0.010	-7.673
% Medicare days	-0.263	0.008	-31.443	0.106	0.008	12.831	0.156	0.008	19.059
Case Mix Index of Hospital	0.136	0.004	34.182	0.109	0.004	27.839	-0.245	0.004	-62.862
HMO Penetration Rate	-0.001	0.000	-17.030	-0.002	0.000	-21.465	0.003	0.000	40.516
IRFs within travel radius (00)	-0.214	0.012	-17.390	0.917	0.012	74.064	-0.703	0.011	-63.253
SNFs within travel radius (00)	-0.038	0.004	-10.824	-0.182	0.004	-49.217	0.220	0.003	66.766
Distance to nearest SNF (00 miles)	0.242	0.023	10.766	0.279	0.022	12.529	-0.521	0.021	-24.912
Distance to nearest IRF (00 miles)	0.050	0.007	7.048	-0.620	0.007	-86.989	0.569	0.007	80.504
No IRFs within travel radius (00)	0.069	0.006	11.862	-0.026	0.006	-4.136	-0.043	0.005	-8.715
No SNFs within travel radius (00)	0.010	0.025	0.407	0.048	0.028	1.750	-0.059	0.024	-2.443
Distance to nearest SNF squared (00 miles)	-0.767	0.039	-19.582	0.352	0.032	10.863	0.415	0.035	11.889
Distance to nearest IRF squared (00 miles)	0.034	0.002	18.438	0.147	0.001	102.546	-0.181	0.002	-99.434

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit)
Lower Extremity Joint Replacement Patients
January 2002 to June 2003
Dead at 120 Days

Dependent Variable	No IRF or SNF			IRF Care			SNF Care		
Independent Variable	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Age	0.073	0.517	0.140	3.085	0.498	6.200	-3.158	0.505	-6.258
Age Squared	-1.338	0.328	-4.082	-1.629	0.329	-4.957	2.967	0.315	9.412
Female	0.525	0.129	4.058	0.132	0.175	0.755	-0.657	0.162	-4.056
Female*Age	-2.359	0.617	-3.825	0.175	0.597	0.293	2.184	0.564	3.869
Female*Age Squared	1.619	0.414	3.910	-0.169	0.396	-0.427	-1.449	0.367	-3.946
Black	-0.077	0.003	-22.431	0.103	0.004	27.352	-0.026	0.004	-7.172
Hispanic	-0.019	0.009	-2.247	0.077	0.009	8.617	-0.058	0.008	-7.441
Other Race	-0.010	0.006	-1.762	0.034	0.006	6.105	-0.025	0.005	-4.605
Beneficiary is covered by Medicaid	-0.100	0.003	-36.160	0.027	0.003	8.701	0.073	0.003	24.294
Lives in an MSA	-0.157	0.004	-40.253	0.079	0.004	20.525	0.078	0.004	22.212
Lives adjacent to an MSA	-0.088	0.003	-29.750	0.032	0.004	8.789	0.056	0.003	16.611
Post-operative pulmonary compromise	-0.074	0.011	-6.855	0.001	0.011	0.069	0.074	0.011	6.694
Post-operative GI hemorrhage or ulceration	-0.032	0.017	-1.860	-0.033	0.016	-2.106	0.065	0.016	4.063
Cellulitis or decubitus ulcer	-0.072	0.011	-6.811	-0.046	0.010	-4.370	0.118	0.011	10.775
Septicemia	-0.156	0.030	-5.130	-0.069	0.035	-1.953	0.225	0.038	5.867
Mechanical complications due to device or implant	-0.061	0.007	-8.462	-0.006	0.007	-0.785	0.067	0.007	8.930
Miscellaneous complications	-0.005	0.007	-0.628	-0.039	0.007	-5.500	0.044	0.007	6.290
Shock or cardiorespiratory arrest	-0.065	0.024	-2.742	-0.017	0.023	-0.760	0.082	0.023	3.604
Post-op heart attack (AMI)	-0.021	0.013	-1.631	-0.001	0.012	-0.106	0.022	0.012	1.912
Post-op cardiac abnormalities other than AMI	0.035	0.035	1.004	-0.032	0.031	-1.026	-0.003	0.030	-0.108
Procedure-related laceration or perforation	0.032	0.023	1.388	-0.023	0.022	-1.040	-0.009	0.021	-0.448
Venous thrombosis or pulmonary embolism	-0.026	0.010	-2.590	0.032	0.010	3.174	-0.006	0.010	-0.610
Iatrogenic complications	-0.036	0.004	-8.675	0.007	0.004	1.640	0.029	0.004	6.946
Sentinel Events	-0.025	0.024	-1.017	-0.013	0.024	-0.547	0.038	0.023	1.639
Acute renal failure	-0.117	0.009	-12.863	0.039	0.010	3.863	0.078	0.010	7.861
Delirium	-0.127	0.006	-20.246	0.028	0.007	4.023	0.099	0.007	14.948
Cancer with a Poor Prognosis	-0.008	0.014	-0.556	0.007	0.014	0.511	0.001	0.013	0.062
Metastatic Cancer	-0.023	0.026	-0.899	-0.025	0.026	-0.963	0.048	0.025	1.893
Chronic Pulmonary Disease	-0.051	0.002	-20.949	0.020	0.003	7.618	0.031	0.002	12.937
Coronary Artery Disease	-0.037	0.002	-17.305	0.030	0.002	13.793	0.008	0.002	3.627
Congestive Heart Failure	-0.080	0.003	-23.325	0.024	0.004	6.703	0.056	0.004	15.810
Peripheral Vascular Disease	-0.043	0.006	-7.695	0.018	0.006	3.071	0.026	0.005	4.674
Severe Chronic Liver Disease	-0.083	0.017	-4.976	0.024	0.018	1.309	0.059	0.020	3.035

Appendix II: Regression Results for Choice of PAC Site (Multinomial Logit)

Lower Extremity Joint Replacement Patients

January 2002 to June 2003

Dead at 120 Days

Dependent Variable	No IRF or SNF			IRF Care			SNF Care		
	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic	Marginal Effect	Standard Error	T-Statistic
Independent Variable									
Diabetes with End Organ Damage	-0.138	0.007	-20.315	0.054	0.008	6.426	0.084	0.008	10.410
Chronic Renal Failure	-0.039	0.019	-2.078	-0.027	0.018	-1.527	0.067	0.019	3.513
Nutritional Deficiencies	-0.130	0.016	-8.247	-0.011	0.017	-0.632	0.141	0.017	8.319
Dementia	-0.125	0.007	-17.335	-0.072	0.007	-11.013	0.197	0.008	25.258
Functional Impairment	-0.146	0.007	-20.988	0.091	0.009	10.606	0.055	0.009	6.442
Diabetes without End Organ Damage	-0.077	0.002	-38.022	0.031	0.002	13.620	0.046	0.002	20.351
Pneumonia	-0.058	0.009	-6.470	-0.020	0.009	-2.271	0.078	0.009	8.879
Stroke	-0.197	0.016	-12.078	0.111	0.021	5.326	0.086	0.021	4.173
Hip Replacement	-0.514	0.025	-20.508	0.388	0.038	10.296	0.126	0.034	3.740
Total Hip Replacement	0.277	0.038	7.268	-0.181	0.030	-6.029	-0.096	0.027	-3.490
Partial Hip Replacement	0.195	0.039	4.939	-0.186	0.024	-7.710	-0.009	0.032	-0.275
Hip Revision	0.328	0.035	9.326	-0.220	0.023	-9.718	-0.108	0.024	-4.478
Knee Replacement	-0.288	0.040	-7.124	0.194	0.033	5.872	0.093	0.032	2.915
Total Knee Replacement	-0.019	0.035	-0.537	0.038	0.028	1.352	-0.019	0.029	-0.672
Knee Revision	0.065	0.038	1.730	-0.029	0.028	-1.012	-0.036	0.028	-1.298
Bilateral Procedure	-0.248	0.002	-104.935	0.214	0.004	51.256	0.034	0.004	8.230
Non-Profit Hospital	0.055	0.002	23.970	-0.111	0.003	-44.070	0.055	0.002	23.383
Government Hospital	0.057	0.004	15.426	-0.088	0.003	-27.476	0.032	0.004	9.049
Average Daily Census of Hospital	-0.014	0.001	-24.606	0.015	0.001	27.886	0.000	0.001	-0.799
Resident to ADC ratio of Hospital	-0.044	0.004	-10.313	-0.001	0.004	-0.272	0.046	0.004	10.741
Percentage of Low Income Patients	-0.080	0.011	-7.337	0.162	0.010	16.331	-0.082	0.010	-7.969
% Medicare days	-0.265	0.008	-31.734	0.109	0.008	13.159	0.156	0.008	19.003
Case Mix Index of Hospital	0.136	0.004	34.005	0.110	0.004	28.069	-0.245	0.004	-62.867
HMO Penetration Rate	-0.001	0.000	-16.835	-0.002	0.000	-21.390	0.003	0.000	40.205
IRFs within travel radius (00)	-0.209	0.012	-17.005	0.909	0.012	73.429	-0.700	0.011	-62.937
SNFs within travel radius (00)	-0.039	0.004	-11.260	-0.180	0.004	-48.686	0.220	0.003	66.573
Distance to nearest SNF (00 miles)	0.237	0.023	10.514	0.289	0.022	12.987	-0.526	0.021	-25.098
Distance to nearest IRF (00 miles)	0.057	0.007	7.955	-0.620	0.007	-87.042	0.563	0.007	79.563
No IRFs within travel radius (00)	0.069	0.006	11.835	-0.026	0.006	-4.095	-0.043	0.005	-8.732
No SNFs within travel radius (00)	0.008	0.025	0.330	0.054	0.028	1.946	-0.062	0.024	-2.621
Distance to nearest SNF squared (00 miles)	-0.760	0.039	-19.437	0.356	0.032	11.064	0.404	0.035	11.576
Distance to nearest IRF squared (00 miles)	0.029	0.002	15.809	0.144	0.001	100.523	-0.173	0.002	-95.026